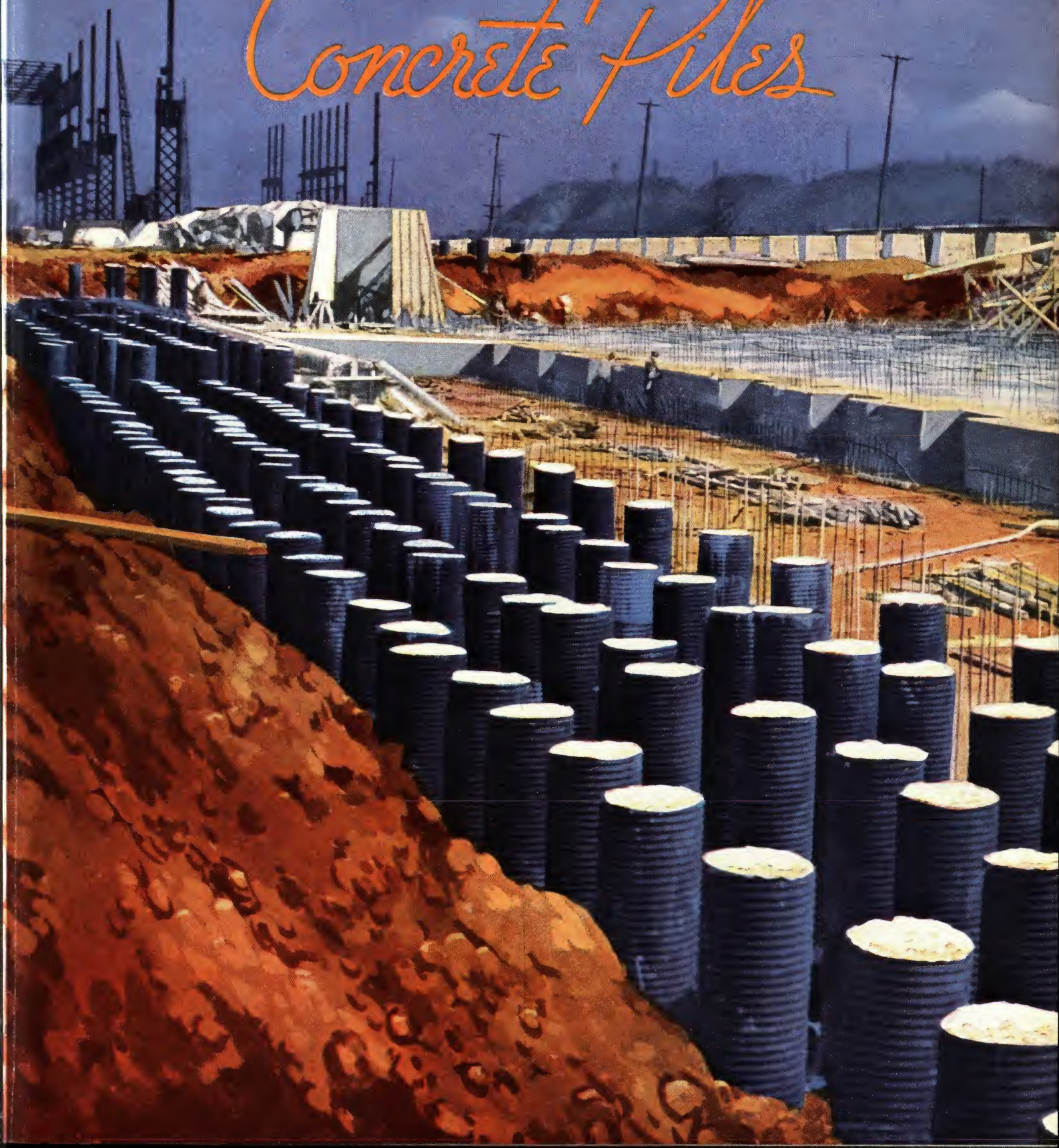


RAYMOND

Concrete Piles



*A form for every pile
A pile for every purpose*



STEP · TAPER · PILE SHELL



Raymond

In the early years of this twentieth century, when the Raymond Concrete Pile Company devised and perfected the type of concrete pile which bears its name and proved to the satisfaction of the construction world that concrete was a suitable material of which to construct and install foundation piles, the Company's business was confined exclusively to that specialty. The success which attended these early activities and the widespread acceptance of the standards and methods developed, pointed clearly toward extension into related lines. The experience gained by the organization and facilities acquired in pursuing the original idea naturally led farther and farther afield from the limited line indicated by the Company's corporate name, to include the design and construction of complete projects involving the original Raymond product, plus those resulting from the development and research always necessary in order to acquire and maintain a position in the forefront of any industry.

For the past quarter century, the name Raymond Concrete Pile Company has meant quality and service in the broad segment of the construction industry defined and illustrated in the pages that follow. The wealth of experience of the Company's Engineering and Construction Staff is at the command of Architects, Engineers and Owners. The co-operation of the Staff, from the preliminary stages of a program, will assure recommendations and plans for the most economical solution of the problem under consideration.

A communication to any one of the offices listed will receive prompt attention.

BRANCH OFFICES:

ATLANTA, GA. 49 Forsyth Street
BALTIMORE, MD. . . S.E. cor. Fayette & Calvert Sts.
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CHICAGO, ILL. 111 W. Monroe Street
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Cimentaciones y Construcciones, S.A.,
Avenida 16 de Septiembre, Num 5,
Despacho 221, Mexico, D.F., Mexico.

RAYMOND

CONCRETE PILE COMPANY

MAIN OFFICE

140 Cedar Street, NEW YORK, N. Y.





RANGE OF ACTIVITIES

RAYMOND

CONCRETE PILE COMPANY

1 RAYMOND TAPERED CONCRETE PILES

Uniformly tapered at the rate of .4" diameter per foot of length from point diameters of 8" or 11" to a maximum of 22.8" diameter at the head, in lengths up to 37' 6"—cast in spirally reinforced steel shells driven against the surrounding soil and left in place.

See pages 21, 22, 23

2 RAYMOND STEP TAPERED CONCRETE PILES

Generally taper 1" to each 8' of length in a series of steps from point diameters of 8" or more to top diameters as may be required—cast in spirally corrugated and plain steel shells driven against the surrounding soil and left in place, in lengths up to more than 100'.

See pages 24, 25, 26, 27

3 RAYMOND COMPOSITE PILES

Cast-in-place (in steel shells as in paragraphs 1 and 2 above) Concrete Piles, superimposed upon wood piles of suitable length to reach firm bearing—the concrete and wood sections being firmly joined by one of several methods, as illustrated.

See pages 19, 20

4 PRECAST CONCRETE PILES

For direct bearing or for retaining wall purposes, as illustrated.

See page 18

5 WOOD PILES AND MISCELLANEOUS TYPES

See page 20

6 CAISSONS AND UNDERPINNING

Gow Caisson Pile

Gow Rotary Bucket Process

Wet Process Caissons by Caisson Contracting Co.—Raymond Company, Consulting & Supervising Engineers.

See pages 29, 30

7 DRILLINGS — BORINGS — SOIL TESTS

Complete service and reports.

See pages 5, 6, 8

8 HARBORS, PIERS, WHARVES, JETTIES, SHORE PROTECTION

Investigations, reports, design and construction in cooperation with owner's engineers.

See pages 29, 30, 34

9 BRIDGES, TUNNELS, TRESTLES, RETAINING WALLS

Representative illustrations.

See pages 31, 32, 34

10 REVETMENTS, DAMS, HYDRO-ELECTRIC PLANTS, AND RIVER IMPROVEMENTS

See pages 31, 32, 34

FOUNDATIONS

Their Importance to the Architect and Engineer

A BUILDING IS ONLY AS GOOD AS ITS FOUNDATION

No matter how well a building is planned or constructed, it is not a good building unless it rests on the proper foundation. Usually it is inadvisable to design a building before tests of the ground at the site are made. Soil tests disclose conditions below the surface of the ground, and if deficiencies in bearing values exist, they are taken into consideration when designing the structure and fixing its location on the site.

If there is ample land available, it has been found advantageous on many occasions to re-locate the building. Rock ledges, out-croppings, springs, quick-sand, fill, soft deposits, etc., are frequently avoided by slight changes of locations on the same site.

NECESSITY FOR ACCURATE INFORMATION REGARDING BEARINGS FOR FOUNDATIONS

Where the foundation goes to an appreciable depth, or the building is large and of permanent character, information regarding the stratum or material upon which the foundation will rest is essential. Sometimes an examination of the sub-soil conditions may be unnecessary, provided

the nature and bearing qualities of the soil in the immediately surrounding area is well known. However, a survey of the load-bearing properties of the soil should be made if there is any doubt or question about the carrying capacity of the ground at the proposed site.

THE ECONOMY OF EARLY TESTS OR BORINGS

Frequently considerable changes have to be made in engineering plans, because accurate information was lacking at the time they were prepared. Load bearing properties of the soil should be studied before plans are drawn

or contracts let. This early testing will save money for the owner by minimizing the possibility of unforeseen and exorbitant extras.

TEST PITS AND BORINGS

As soon as the general plan of the building has been established, and the location of deep excavations or concentrated loads determined, the lines of the foundation should be laid out on the property.

The nature of the ground below the surface should then be ascertained. Several methods are available. One is by

digging test pits to the depth of the ordinary foundation, or to a solid bottom, at a number of predetermined points. If the bottom is unsatisfactory, it is necessary to ascertain the character of the underlying material.

This can best be determined by borings, or drillings, as fully described on pages 6 and 8.



OFFICE BUILDING Houston, Texas
John Ebersson, Architect
Supported on
1346 RAYMOND CONCRETE PILES

A Form for Every Pile . . . A Pile for Every Purpose

2

3

SOIL TESTS

Soil tests to determine the load-bearing qualities of the soil at different levels are often desirable.

Samples of the sub-soil, or core-drilled rock samples, may be tested in the laboratory to determine their safe load values. Often there are found strata of different na-

tures, some of which would be good for heavy loads. Below these, however, there may be a weaker stratum or a water condition precluding economical excavation. This may necessitate the use of piles driven to solid bearing.

UNDERPINNING

Carrying the foundation of a building below that of the adjoining buildings is the usual object of underpinning. It may be required, also, because of changes in soil conditions due to the digging of subways, construction of deep sewers, lowering of the water level, etc. Such condi-

tions often entail considerable trouble and expense. Competently handled however, underpinning can usually be installed without serious disturbance of adjacent property. This type of service is described in greater detail on later pages.

FOUNDATIONS FOR ENGINEERING PROJECTS

In the engineering field it is vital to have, at an early date, accurate information regarding bearing conditions. It is one of the first requirements in determining the location of a bridge or tunnel or any important structure.

The reports on sub-surface tests may determine the practicability of a proposed location, not only from the engineering standpoint, but from the economic viewpoint as well.

TESTS AND BORINGS FOR BRIDGES, TUNNELS, RETAINING WALLS, DAMS, PIERS, JETTIES, HARBORS, ETC.

The type of information required for such a wide variety of projects demands the broadest experience in this class of work. While it is true that every project presents an

individual and a different problem, the company with the widest experience is obviously best qualified to analyze specific conditions and to make sound recommendations.

IMPORTANCE OF EXPERIENCE IN INTERPRETING BORINGS AND SOIL TESTS

It requires far more than the mere testing of samples in a laboratory, to determine the value of the bearing strata disclosed. For example, in the case of piles driven through various strata, it is necessary to know how the resistance developed by the driving of the pile will react in each stratum. As a matter of fact, accurate deductions and calculations for foundations, with or without piles, can be made only when exact performance records of driving and load tests are analyzed in the light of long and varied experience. In interpreting borings and soil tests there is *no substitute for experience*.

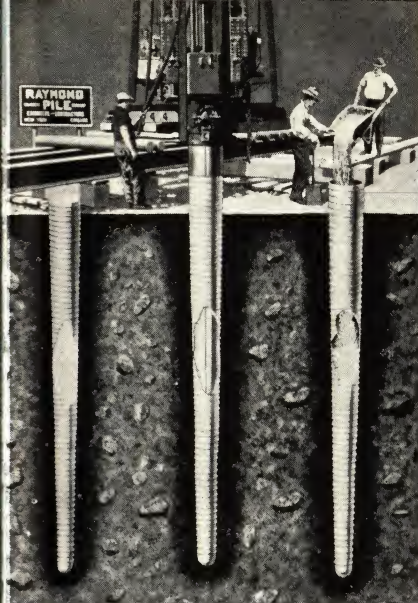
OBTAINING UNBIASED FOUNDATION ENGINEERING SERVICE

The engineering organization making tests such as those described should have three major qualifications. First—long and broad experience; second—a reputation for integrity; and third—an absolutely unbiased attitude regarding the condition under consideration. The Raymond Concrete Pile Company has made tests of every description, and has installed foundations of every kind in every section of this country, and in many foreign countries as well. Raymond representatives are therefore competent to advise with architects, engineers, and owners, and to offer suggestions free from bias. While the Company is interested in the installation of various types of concrete piles, caissons, and poured foundations, it will always endeavor to recommend the *proper* type of foundation, as shown by the test borings, whether piles are required or not.

A last word: Whether the Raymond Company, or one of the other reputable engineering testing organizations, makes the tests, or designs the foundation, we urge that accurate data be obtained at an early stage.

CITY HALL, Atlanta, Georgia
G. Lloyd Preacher & Co., Architects
Supported on 290 RAYMOND CONCRETE PILE

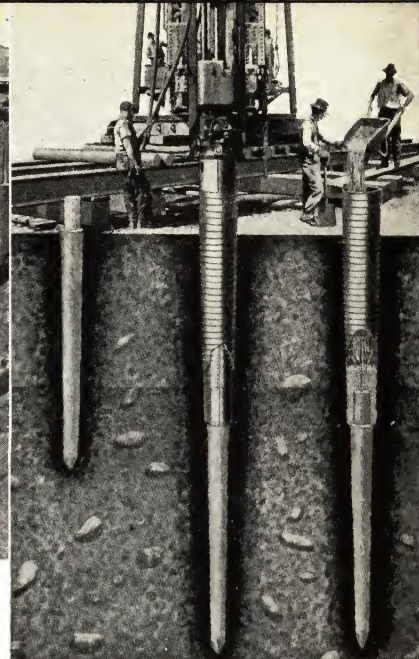




RAYMOND TAPERED Concrete Piles:—Center, completely driven—LEFT, Unfilled Shell ready for Inspection—RIGHT, Pouring Concrete.



GOW CAISSONS, ready for foundation beams—Caissons belled out in rock approximately 40 feet below surface and built up 20 feet to grade—diameter 4 feet (Note illustration at left) Hillside site, later filled to caisson top—Junior High School, Scranton, Pa.



RAYMOND COMPOSITE Piles—LEFT, Driven Wood Section—CENTER, Driving complete—RIGHT, Pouring concrete.



GOW CAISSON PILE, ready for Inspection and Concrete.

TYPES OF FOUNDATION SERVICE

OFFERED BY
RAYMOND
CONCRETE PILE COMPANY



Rotary Drilling for WET PROCESS TYPE CAISSON (Note water connection to drill stem).



GOW ROTARY Excavator bucket emerging from ground with load of excavated material (Note clay overload from reaming knives).



A group of Standard RAYMOND TAPERED Concrete Piles ready for the concrete footing to be poured—Note the spirally reinforced steel shell with reinforcing wires 3 inches on centers, remaining permanently in place.

BELOW—A supply of heavy gauge 24 foot shell sections for RAYMOND STEP TAPERED Piles, ready to be assembled on the driving core—Note screw threads at open end for attachment to upper sections.



Installing GOW CAISSON PILES.

A fleet of eight RAYMOND Steel Drivers on a job consisting of more than 18,000 RAYMOND TAPERED and STEP TAPERED Piles, totaling in length more than 723,000 lineal feet and completed in 124 calendar days—December 9, 1936 to April 12, 1937.



TEST BORINGS AND SOIL INVESTIGATION

2
3



"Light equipment
is used to procure
samples of . . . ground"

The Gow Division of the Raymond Company is the successor organization to the Gow Company of Boston, outstanding in soil investigations for more than twenty-five years. This division is well equipped to carry on such investigations.

As explained on preceding pages, dependable soil information is indispensable to the proper design of foundations.

Borings are of two general types:

1st: EARTH BORINGS. Wherein light equipment is used to procure samples of soft ground. The samples are obtained by driving a specially designed sample spoon into the earth thru a guide casing, and reclaiming characteristic samples in as nearly the actual state existing at the various depths as is practicable.

2nd: CORE BORINGS. Which are resorted to when it is necessary to penetrate thru boulders, hard pan, etc., into ledge rock, and to recover cored samples of the ledge.

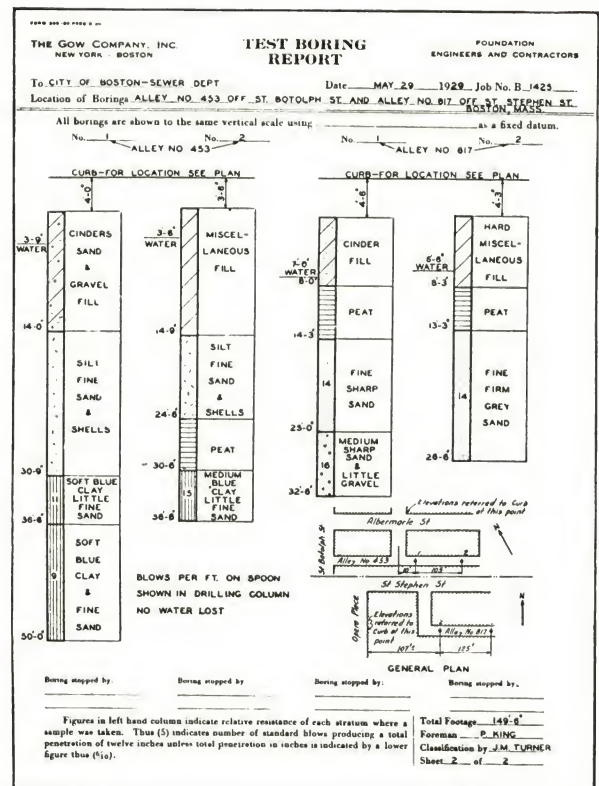
In either case a complete log is kept of the soils encountered, together with their geological classifications and other pertinent information, such as water levels. The log is submitted in the report that accompanies the boring samples.

LABORATORY ANALYSIS OF SOILS

A recent development here and abroad has been the laboratory analysis of soils. For such work large soil samples from 3" to 5" in diameter are required. The Gow Division has developed equipment and methods for obtaining these large "undisturbed samples" and has had extensive experience in this recent scientific advance.

TEST PITS AND SOIL BEARING TESTS

The Gow Division is equipped to excavate test pits for shallow soil investigation, and to conduct soil bearing tests. The latter are made by loading pre-determined areas of a proposed bearing stratum in small increments, and recording settlements corresponding to the load increments. An important consideration in soil bearing tests is the proper size of the area to be loaded. It is essential that bearing tests be conducted in the manner that most nearly approximates the actual conditions under which it is proposed to load the stratum of soil under test.



THE ALLOWABLE LOAD

The allowable load per pile is naturally one of the first matters to be considered in a pile foundation. No hard and fast rules can be laid down and followed. The character and general purposes of the structure, the nature of the soil to be penetrated, and the bearing strata reached, as well as the size, shape, length, and type of the pile under consideration, are determining factors. The most

generally accepted unit loading for concrete piles is 30 tons per pile. Under certain conditions, peculiar to a specific site, unit loads may have to be somewhat reduced, while under others, greater loads may be carried safely. Long experience with every sort of condition is of greater value than theory in determining the allowable load per pile.

COMPREHENSIVE LOAD RECORDS AND TEST DATA

In its more than thirty-five years of pile driving, under the greatest variety of soil conditions and locations, the Raymond Concrete Pile Company has acquired information, records, and test data of inestimable value to clients.

Discussions regarding projects in contemplation will be welcomed by our organization, and should prove materially helpful to anyone concerned with a foundation problem.

DETERMINING CARRYING CAPACITY OF CONCRETE PILES

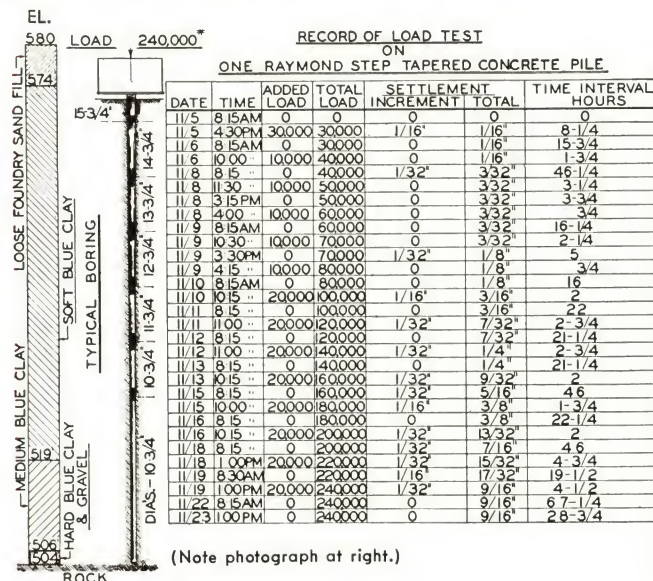
The carrying capacity of concrete piles under given conditions need not, and should not, be a matter of guesswork. Carrying capacity can be safely determined, provided always that correct methods of construction are followed. Well known formulae may be considered as a general guide but must be interpreted in the light of wide experience. The formula generally used is known as the "Engineering News Formula," based upon the use of a single-acting steam hammer, as follows:

$$L = \frac{2WH}{S+0.1}$$

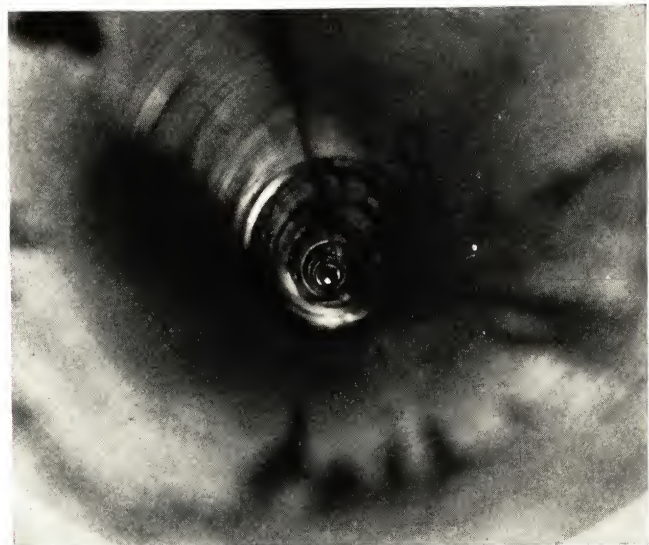
L = Safe load in pounds.
 W = Weight of falling parts in pounds.
 H = Drop in feet of falling parts.
 S = Final penetration per blow in inches.
 In a No. 1 steam hammer, $W=5,000$ and $H=3$
 In a No. 2 steam hammer, $W=3,000$ and $H=2\frac{1}{2}$

Ordinarily, Raymond piles are driven to four blows to the last inch with a No. 1 steam hammer, for a working load of 30 tons per pile, thus adding 43% to the safety factor of the formula.

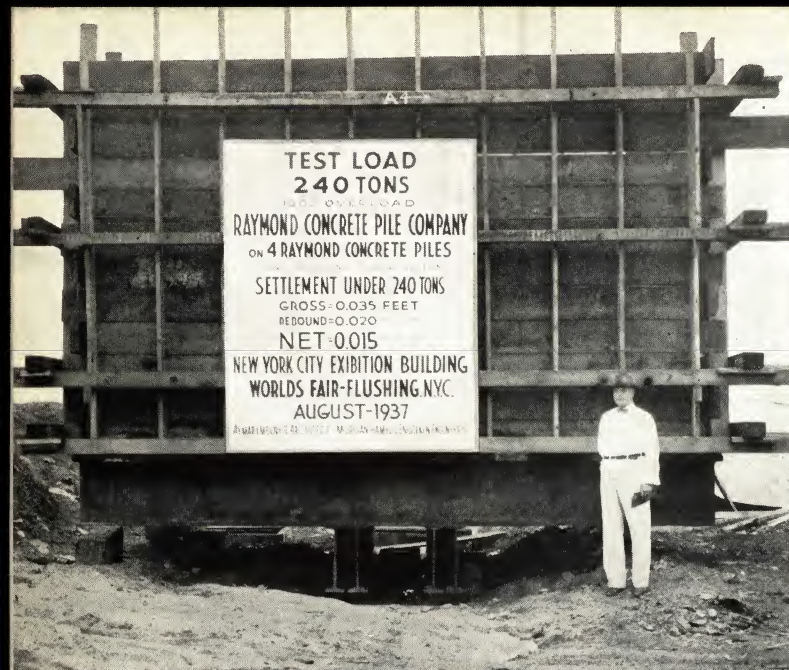
QUOTATION FROM ENGINEER'S REPORT "**** loading was continued to a total of 120 tons *** Test was then stopped, as the platform was not designed to take any more load." Final net settlement, after allowing for elastic compression, as evidenced by recovery on removal of load, was 3/16 inch. The lower 24 feet of shell was 10 gauge plain strip steel and the upper sections Standard Raymond STEP TAPERED spirally corrugated shells in gauges from 14 to 20. (Test made at Great Lakes Steel Corporation plant, under supervision of Steel Company Engineers.)



Inspecting driven STEP TAPERED Shell, which when filled with concrete, formed a pile such as loaded and tested per record at left—Bottom of shell showing small white spot, 68 feet down.



A Form for Every Pile . . . A Pile for Every Purpose



$\frac{2}{3}$

TEST PILES

TEST PILES GENERALLY NOT NECESSARY

Load tests for pile carrying capacity may be very useful and may be advisable under certain conditions but may be unnecessary under others. Any test load should be appraised in connection with the character of material in which the pile finds its bearing.

A test on a single pile sustaining, without more than allowable settlement, a load of 50% to 100% in excess of the designed working load, is usually conclusive if the

following questions can be answered affirmatively:

- (1) Is the material below the point of the pile of a nature which will not compress or subside under the accumulated load on all the piles to be driven?
- (2) Is the piling method such as to insure all piles being driven alike, determinable by inspection after driving?

EXPERIENCE IN DRIVING PILES MAY BE MORE RELIABLE THAN TEST PILES

If the soil in which the pile has its bearing is reasonably uniform or well known, and the underlying soil is free from vegetable matter, and *if the method followed is such that it can be known that no injury is suffered in driving*, it is usually a waste of money to make load tests. Experience has shown that driving to a uniform resistance will serve all practical purposes. Piles of the same bearing value may vary greatly in length. Length flexibility can only be economically obtained by using cast-in-place piles,

which provide the required bearing value with a minimum of waste, since the length of cast-in-place piles need not be pre-determined.

On the other hand, if pre-cast piles are used, in lengths indicated by one or more load or driving tests, there is always the possibility that they may not be adaptable to even normal length variations. They may prove to be too short in some places, and too long (and thus partially wasted) in others.

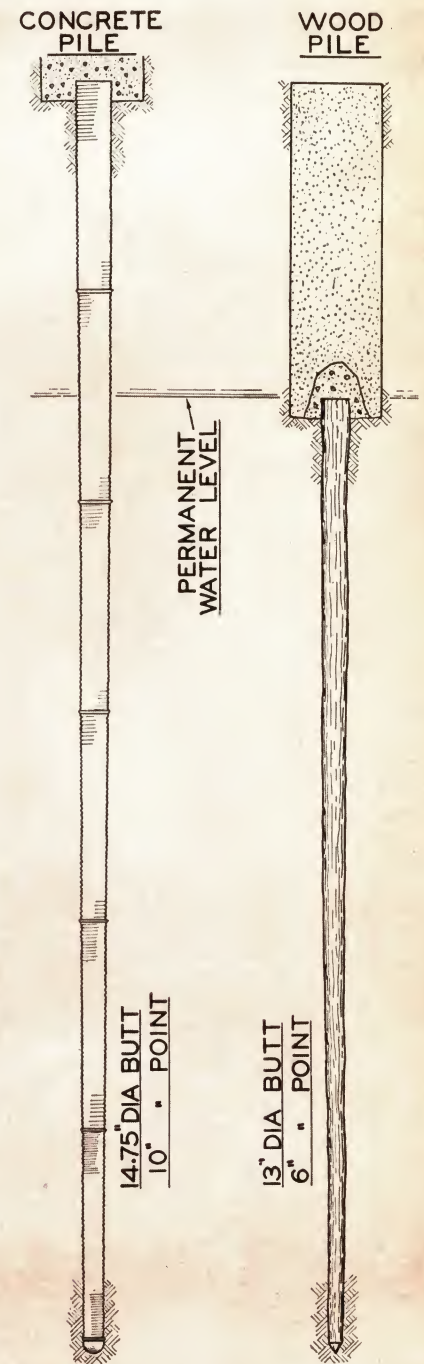
CONCRETE PILE ADVANTAGES

Concrete Piles, *when installed by correct and proven methods*, have many points of advantage as compared with wood piles. Among these are:

1. **ABSOLUTE PERMANENCY**—not being subject to decay or to attacks of wood borers and destroyers.
2. **GREATER CARRYING CAPACITY**—meaning a less number of piles for a given load.
3. **SMALLER AND LIGHTER FOOTINGS**—because of decreased number of piles, with consequent decrease in dead loads to be carried.
4. **DECREASED LENGTH OF PILE**—as a natural consequence of greater size and displacement.
5. **ELIMINATION OF SHORING, UNDERPINNING, SHEETING, PUMPING AND DEEP EXCAVATION**—required to cut the wood piles off at permanent low water.
6. **THE CENTER LINE OF COLUMNS CAN BE BROUGHT NEARER TO THE BUILDING LINE**—due to decreased number of piles, and consequent reduction in width of wall footings.
7. **IMPORTANT SAVING IN TIME.**

PERMANENCY OF CONCRETE PILES

The permanency of concrete piles, regardless of moisture conditions, naturally eliminates the excavation, sheeting, shoring and pumping necessary, in the case of wood piles, to reach a cut-off below permanent water level. The concrete pile heads can be left at an elevation only sufficiently below the floor line to permit of the proper distribution of loads.



11



LEFT—Rotting Wooden Piles on Site of Cattle Penn Building. Pennsylvania Railroad Philadelphia, Pa.

GREATER CARRYING CAPACITY

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3

The claim to greater carrying capacity rests upon several points:

- a. Greater size, therefore greater displacement.
- b. Perfect shape—of uniform size and straightness—thus insuring full ground contact and centering of the load over the point of the pile.

c. Possibility of inspection after driving, hence the ability to load to greater capacity, instead of making allowances for inefficiency as in the case of wood piles, which are subject to injury by overdriving, telescoping, departing from the vertical and like defects, none of which are discernible after driving begins.

CENTERING OF COLUMNS

All designers will appreciate the advantage of keeping their column centers as near as possible to the center of gravity of the pile groups, thus reducing, and in many cases avoiding, expensive cantilevers. This is no small

consideration when wide footings and limited property lines result in eccentric loads which cannot be otherwise provided for.

SAVING IN TIME

The principal reasons for the saving in time mentioned under Item 7 are:

- a. The smaller number of piles required.
- b. The reduction in quantities of excavation, shoring, sheeting and pumping.
- c. The reduction in quantities of footings or masonry.
- d. The manufacture of the piles in place, from materials readily procurable in all localities, and the limiting of manufacture to the actual number and length of piles required. This obviates delay for cutting and trimming trees, hauling to shipping point, transporting for great distances by rail or water and delivery to the job—perhaps only to find that the piles are too long or too short.

There is no business in which the expression "time is money" more truly applies than in the construction industry. The contractor's daily expenses are high, and the

owner frequently gains a day's income for the entire completed structure for each day that can be saved in construction.

It is frequently the case that a concrete pile foundation can be completely installed in less time than would be required for the necessary materials for a wood pile foundation to be delivered to the site.

The Raymond Company, with its organization and equipment so widely distributed over the United States, is in a particularly favorable position to give prompt service and has a reputation for completing its contracts on time.

Rapidity of work is always more or less governed by local conditions, such as the character of the soil to be penetrated and the length and spacing of the piles. It is, therefore, impossible to give accurate figures that will apply to all conditions under which concrete piles are placed.



WOOD PILING AND SHIFTING WATER LEVELS

That wood piling will (unless exposed to the attacks of subaqueous "borers" or other deleterious conditions) be permanent if constantly saturated or submerged, has been shown by specimens exhumed by archeologists and others. However, the difficulty of MAINTAINING SATURATION is a problem that is becoming more and more serious.

Apropos this problem, attention is called to the following excerpts from engineering papers of many years past.

In an editorial entitled "Wood Piling and Ground Water Levels," *Engineering-Contracting* of April 13, 1910, says:

"A point not so often allowed for ***** is the change in water level that is likely to occur, particularly in large cities where sewers, subways, and other structures affecting underground water level are continually being constructed. ***** It cannot be too confidently assumed, however, that piles whose tops are well below water when the foundation is built will still be below water level a few years later.

"***** In tearing down recently a building constructed some ten years ago in Milwaukee on pile foundations, the pile tops were found some 3 feet above the water level, though when the building was constructed they had been placed below it. *****

"***** Ground water levels depend entirely on drainage conditions, and in cities drainage conditions are seldom the same for any long time. *****

An article published in *Cement Age*, of April, 1910, under the heading of "Prevention and Cure of Weak Foundations," not only reiterates the warning conveyed by *Engineering-Contracting*, but goes further in describing specific instances of buildings settling as a direct result of defective wood piling foundations, impaired by changes in ground water levels. The writer says in part:

"Wood piles form a satisfactory foundation as long as they are below the ground water level, but when the water level lowers and the piles are exposed to the atmosphere, they deteriorate rapidly ***** invariably necessitating extensive repairs. ***** It is most gratifying to know that modern engineering has developed efficient and economical methods of prevention as well as cure for these dangerous and costly troubles.

Right:

Old wood piles in Pier No. 6 and No. 7, Central Harlem Health Center, New York City. Water level 2 ft. below water shown in picture. Note condition of all wood piles.



CONCRETE PILE ADVANTAGES (Continued)

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"A remarkable instance of the lowering of the water level away from pile foundations because of tunnel construction occurred at the old Cambridge Hall Building, Thirty-third Street, directly opposite the Waldorf Building. The Thirty-third Street wall of this building was supported on wooden piles. Settlement took place in the building during the construction of the Thirty-third Street cross-town tunnels, which went directly in front of the building.

"After the tunnel excavation had been completed, and the permanent masonry lining built in place, it was thought that the stream which had been flowing into the tunnel the year before would back up and again submerge the piles. The borings, however, indicated that this was not so, for the tunnel had in some manner effectually and permanently diverted the old stream and lowered the ground water level.

"***** When the contract was let for the underpin-

RAYMOND TAPERED CONCRETE Piles in abutment of Glendale-Hyperion Viaduct over Los Angeles River—Note five rows of battered piles in background.

14

(Below)—A six-pile pier of RAYMOND STEP TAPERED CONCRETE Piles.



ning, the contractor expected to encounter water and to sink the cylinders under the wall by the pneumatic process. When the work was done, however, no water was found *****. The water table had been lowered on account of the tunnel construction about 24 feet.

"***** Modern buildings, especially in New York City, require greater support than can ordinarily be secured by wood piles."

The writer then enumerates the preventive methods available for use in guarding against conditions of the nature described. He continues:

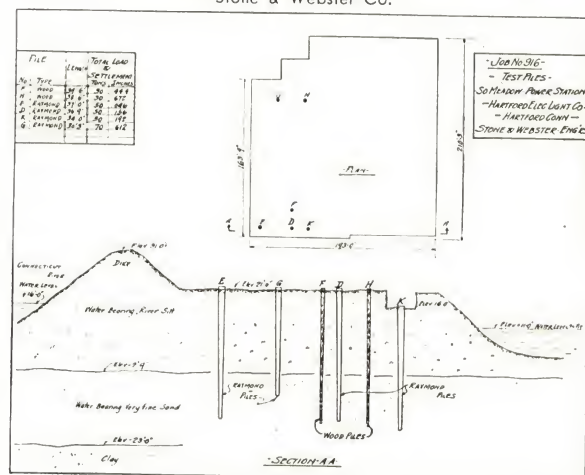
"Prevention of the unsatisfactory conditions resulting from the use of wood piles is found in the substitution of concrete or other artificial supports which are unaffected by changes in water level *****.

"Concrete piles have been coming rapidly to the front as combining the necessary elements to most successfully solve this problem. *****"

CONCRETE PILES vs. WOOD PILES



Comparative Test of Wood and Concrete Piles. Test made by Stone & Webster, Engineers, Hartford Electric Light Company, Meadow Power Station, Hartford, Conn., F. D. Knight, Supt., Stone & Webster Co.





Above: BANK AND OFFICE BUILDING —
Greensboro, N. C.
C. C. Hartman, Engineer
Supported on 1242 RAYMOND CONCRETE
PILES



Above: FAIRFAX HOTEL — Pittsburgh, Pa.
Philip M. Julian, Architect
Supported on 716 RAYMOND CONCRETE PILES

Right: MEDICAL ARTS BUILDING —
Omaha, Nebraska
Thomas R. Kimball, John McDonald &
Allen McDonald, Architects
Supported on 981 RAYMOND CONCRETE
PILES



Below: SEARS ROEBUCK BUILDING — Miami, Florida
Nemmons, Carr & Wright, Architects
Supported on 471 RAYMOND CONCRETE PILES



Above:
EQUITABLE LIFE BUILDING
Des Moines, Iowa
Supported on
1478 RAYMOND CONCRETE
PILES

Left: L. C. SMITH
OFFICE BUILDING
Seattle, Washington
Supported on
1281 RAYMOND CONCRETE
PILES



CONCRETE PILE CLASSIFICATIONS

CONCRETE PILE CLASSIFICATIONS

Concrete piles are of two distinct types:

1. Piles which are poured or cast in forms previously driven into the ground, commonly referred to as "cast-in-place" concrete piles.
2. Piles which are cast in forms, above ground, and then driven like wooden piles, referred to as "pre-cast" concrete piles.

CAST-IN-PLACE PILES

"Cast-in-place" piles are further divided into two classes:

- (a) Those in which a form is driven in contact with the soil and left in the ground to preserve driving compression and the integrity of the finished pile, and
- (b) Those in which the concrete is placed by means of a *temporary* driving form which is removed before the concrete hardens and leaves the pile confined *only* by the loose earth. The green concrete is then, obviously, subject to the admixture of foreign materials, excess of water, and distortion due to strains set up by soil pressures and the *driving of adjacent piles*. A modification of this latter type is the insertion, in the temporary driving form, of a smaller form which is filled with concrete prior to the removal of the temporary form. This "smaller form" obviously does not maintain the original driving compression, nor the resistance under the hammer which would otherwise be a dependable measure of the sustaining power of the pile.

THE RAYMOND PILE AND THE PERMANENT FORM

The Raymond pile is the outstanding example of the (a) type involving the use of a permanent form, commonly referred to as a "shell." The *driven* steel shell left *permanently* in place is essential to dependable results, because:

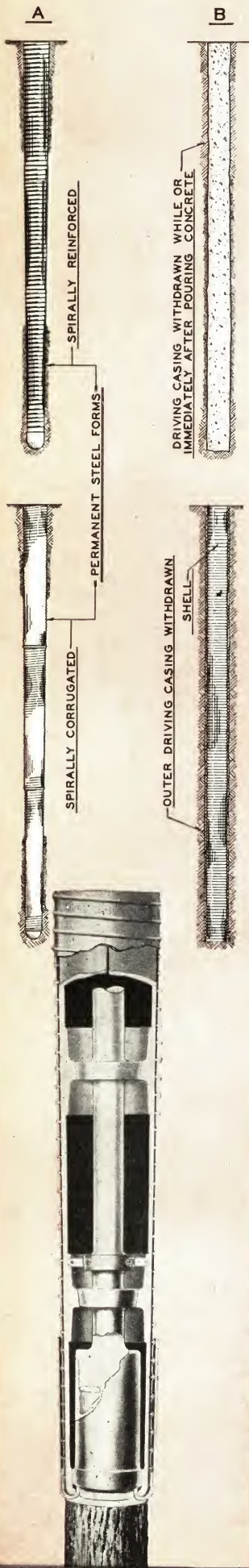
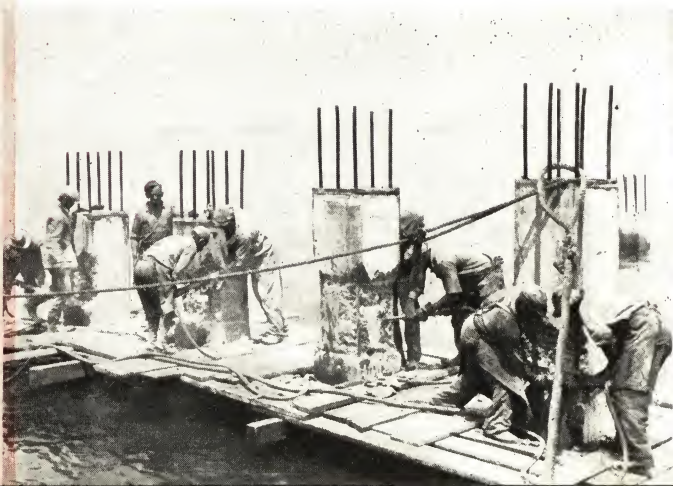
1. It serves as a form for the piles.
2. It prevents the admixture of foreign substances with the concrete, and protects it from excess of ground water during the cement setting period.
3. It retains the original moisture in the concrete until it is thoroughly hardened.
4. It prevents distortion by external pressure, due to the driving of adjacent piles or accumulated pressures from displacement by the pile itself.
5. It retains perfectly the displaced earth forming the walls of the cavity, so that there may be no relaxation of the ground and, therefore, no loss of the original driving compression.
6. It acts as reinforcement of the pile until the concrete shall have attained its maximum strength.

16

← COMPOSITE

PRECAST

CAST IN PLACE



CLASSIFICATIONS (Continued)

THE NEED FOR THE PERMANENT SHELL FOR PILES

It should only be necessary to point out the functions of the shell, to make clear that, in the cast-in-place type (b) where no shell is used, or where a shell is placed loosely in the ground, vital safeguards are omitted in order to effect a saving in first cost. *All the points raised as to the necessity and value of the shell apply with equal force as arguments against its omission.*

LIABILITY OF DISTORTION

Any one who has ever seen a pile core, or a pile, driven 20 or 30 feet into the ground and immediately withdrawn, will probably have noticed that the earth at once closes in partially. This earth movement is an attempt to return to its former position. Should soft concrete be poured into the opening thus left, the returning earth movement is apt to produce distortion before the concrete sets. This has frequently been demonstrated by the exposure of concrete piles poured without a protecting form. Because of the differences in density and, consequently, in resiliency, of the various soil strata, the distortion is often very unequal. Diametric measurements have varied from 3 or 4 inches to 3 feet from an original diameter of 14 to 16 inches.

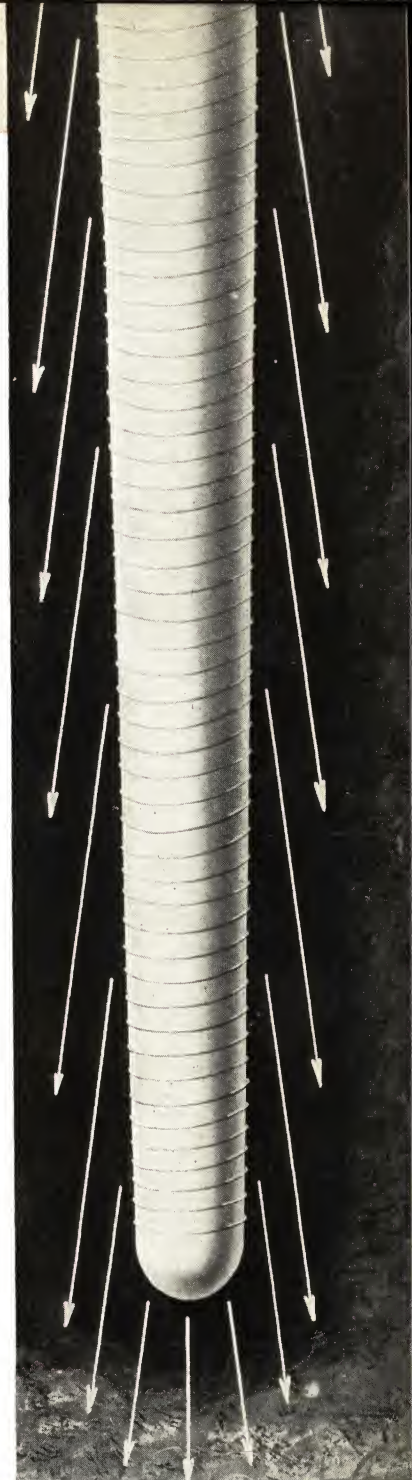
The half-way measure of inserting a shell of smaller diameter into the temporary driving form protects the concrete from many of the hazards attending the omission of the permanent shell in contact with the ground. However, it is of uncertain value, due to the resulting void and the unavoidable loss of intimate contact with the ground. There may be instances in which point-bearing without lateral support can be relied upon, but in by far the greater number of pile foundations, the carrying capacity of the piles results from (1) compression developed in driving, and (2) friction from contact with the surrounding soil. The resultant frictional resistance is of questionable value, *unless* the substance opposed to the ground during the driving process remains in place to retain its intimate contact.

CALCULATING DRIVING RESISTANCE

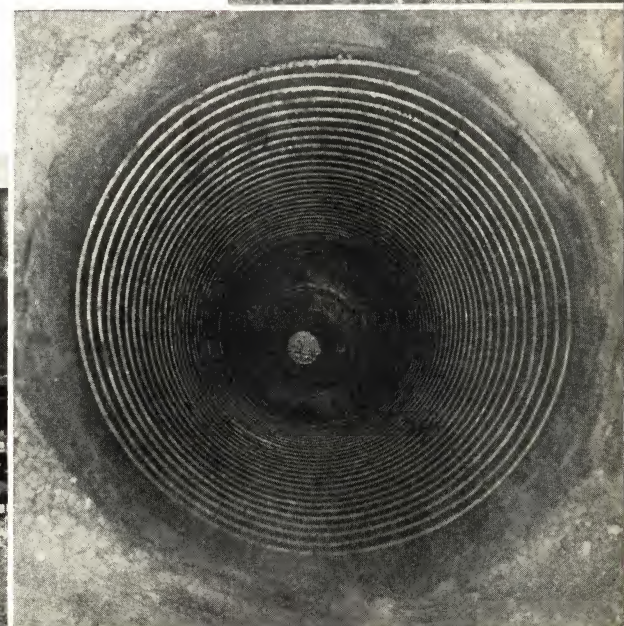
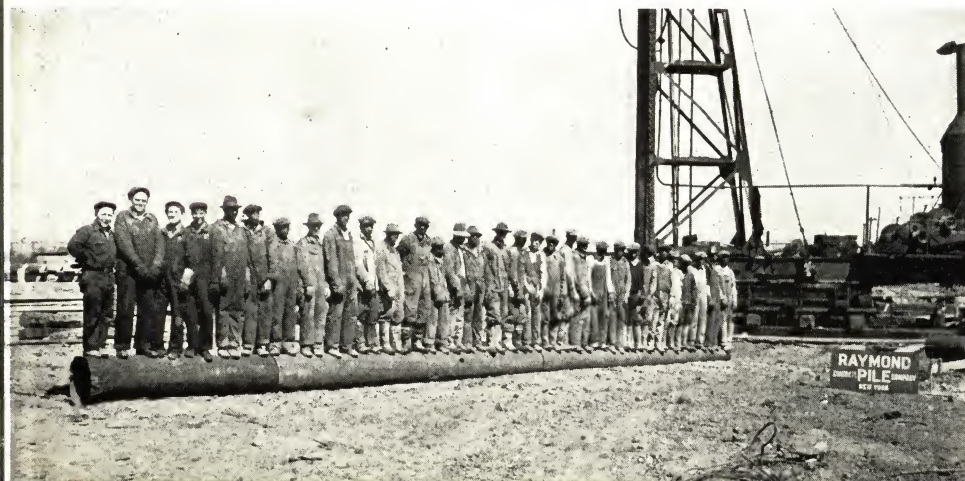
Driving resistance can be accurately measured for any pile and can be analyzed in accordance with well established engineering practice. However, if the compression of the soil on which this resistance depends is released, by withdrawing a temporary outside driving form, the *original* driving resistance cannot be depended upon as an accurate measure of the *final* supporting power of the pile.

Close up of lower end of RAYMOND TAPERED CONCRETE Pile—Note arrows indicating direction of forces due to tapering wedge shape.

What the Inspector sees—Day-light photograph down the interior of driven 30' RAYMOND TAPERED Shell—Note spiral reinforcing—light spot at bottom is film of water poured in for reflection purposes when light is strong enough to make lowered electric inspection light unnecessary.



A striking illustration of the value of "spiral reinforcing" in the shell of a RAYMOND TAPERED CONCRETE Pile—without this reinforcing, the weight of any one or two of the 30 full grown men would have collapsed the thin sheet metal tube.



2 PRECAST PILES

3 Pre-cast piles have a large and useful field in the construction of docks, bulkheads and other marine structures, and less frequently are used in foundation work. Generally a water jet is used to assist in securing the desired penetration, and to minimize damage from repeated shocks of the hammer.

With piles of this type it is necessary to determine from four to six weeks in advance of driving, just what length of pile to cast, and experience shows that this pre-determination can seldom be made accurately. This naturally results in either excessive expense in providing longer piles or great waste in cutting them off. It is sometimes possible, by means of excessive jetting and driving, to

secure sufficient penetration to avoid cutting off a pile cast longer than necessary, notwithstanding the fact that a shorter pile might well have served the purpose if wholly driven to necessary resistance. In such cases, the waste of money is obvious.

If pre-cast piles are driven without the use of the jet, it is necessary to cushion and protect the head to avoid damage from the driving impact. This cushion, or protection, naturally absorbs an appreciable part of the energy of the hammer blow and consequently prevents accurate calculation of the carrying power of the pile from a record of the penetration under each blow.

DRIVING PRECAST PILES

Since it is impracticable to subject the pre-cast pile to the same solid driving shock as the cast-in-place pile, it follows that it is impossible to safely develop the same resistance to static load. It therefore seems logical that calculable bearing values are less easily established than with the cast-in-place pile where the concrete is not sub-

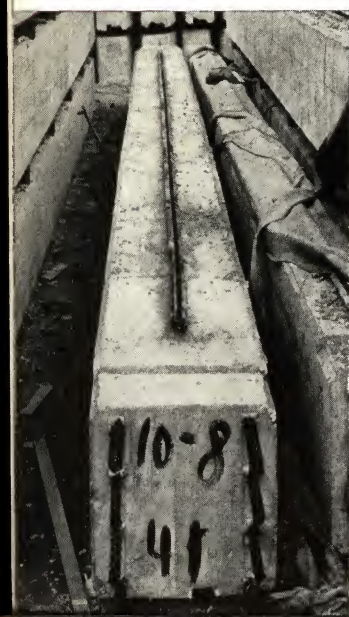
ject to impact.

Disregarding the items of waste referred to above and the possibility of injury to piles in transporting, driving and handling, cast-in-place piles are generally economical by comparison, even though their price per lineal foot may be greater than that estimated for pre-cast piles.

18 Reinforced Concrete Sheet pile with steel interlock, for cut-off wall—Note heavy projecting reinforcing rods for embedment in bulkhead beam which surmounts line of sheet piles after driving is completed.

Under view of 4375' Reinforced Concrete Bridge, Punta Gorda, Florida—Note perfect alignment of precast piles and girders.

Under view, reinforced concrete pier at Charleston, S. C. Navy Yard—Note excellent alignment of precast concrete vertical and spur piles.



COMPOSITE PILES

This type of pile, as its designation implies, comprises a concrete pile superimposed upon a wood pile. The respective lengths of the concrete and wood sections depend on the elevation of permanent water level in relation to the ground surface, and the depth at which firm bearing may be reached. In general, the load is carried by the wood pile, the concrete section acting as a column through that portion of the soil not continuously saturated.

Piles of this type came into general use after 1917, when the Raymond Company placed several thousand, ranging up to 100 feet in length, in the foundations of blast furnaces, ore bins, trestles, power house, repair shops, etc., in a large industrial plant. The site was underlain by hardpan and rock at depths varying from 75 to more than 100 feet below the surface. From the surface down to the hardpan stratum, the soil was of soft yellow and blue clay, practically incompressible, flowing under heavy pressures, and heaving under the displacement of

the piles to practically the extent of their volume. Under these conditions, composite piles seemed, at the time, to furnish the only economical solution and proved entirely adequate. (Note: An all-concrete pile would have been desirable but would have been prohibitive in cost if of any type then in commercial use. Since that time, however, a type of pile known as the Raymond Step Taper Pile has been developed and is fully described on subsequent pages.

The concrete section of the composite pile may be either cast-in-place or pre-cast, and may be straight-sided or tapered. There are soils whose characteristics are such that friction and compression are of a certain value and in which it is practicable to develop that value by means of a tapered concrete section, thus justifying a greater load per pile than that ordinarily allowable on the wood pile alone.

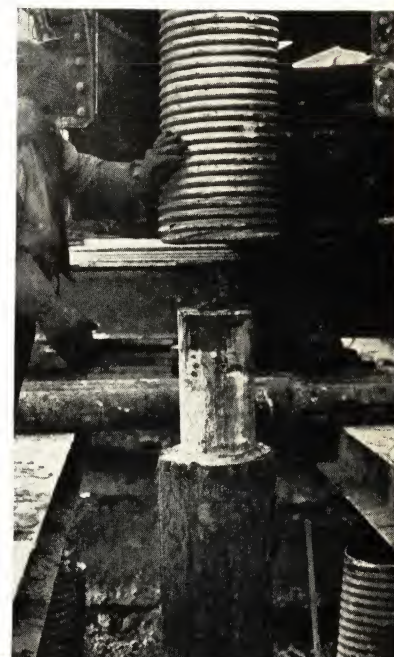
ECONOMY OF CAST-IN-PLACE UPPER SECTIONS

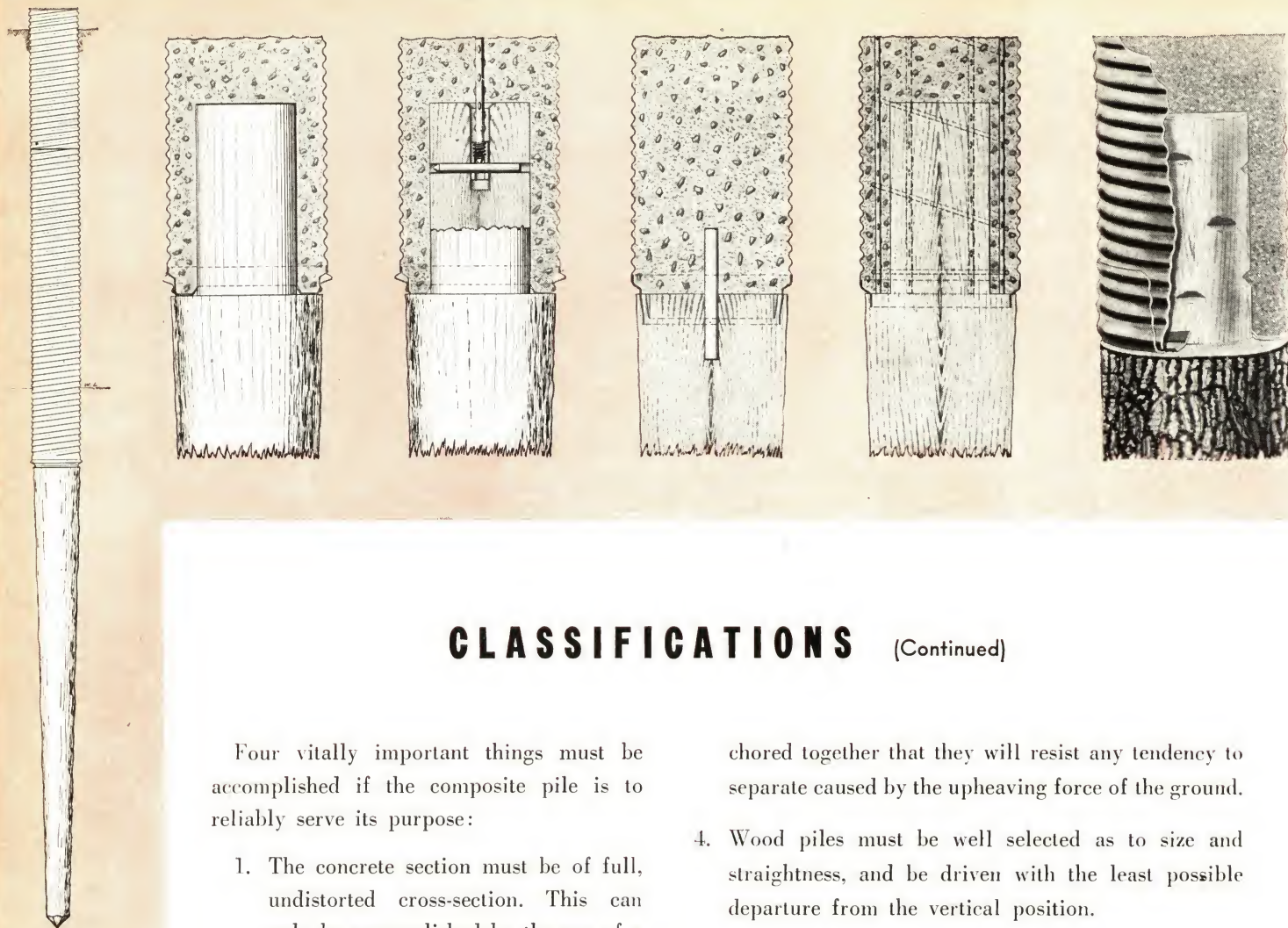
Pre-cast upper sections are seldom economical and seldom used because they are expensive to construct and handle, and because lengths must be predetermined. The cast-in-place upper section is therefore preferable, since

its length can be varied as required. Should the wood pile section fail to reach firm bearing at the expected length, the concrete section, if cast-in-place, may be correspondingly increased in length.

Below: Wood sections of composite piles, with machine cut tenons, ready to be handed to driver and driven.

Right: Driven wood section of composite pile and shell enveloped core being lowered over joint tenon for final driving to elevation at which wood section is entirely below permanent water level.





CLASSIFICATIONS (Continued)

Four vitally important things must be accomplished if the composite pile is to reliably serve its purpose:

1. The concrete section must be of full, undistorted cross-section. This can only be accomplished by the use of a shell left permanently in place.
2. The joint between the concrete and the wood sections must be clean and free from water, mud, sand, or other foreign substances.
3. The two sections must be so an-

chored together that they will resist any tendency to separate caused by the upheaving force of the ground.

4. Wood piles must be well selected as to size and straightness, and be driven with the least possible departure from the vertical position.

Due to the fact that composite piles carry the greater part, and frequently all, of their load on the wood section, it is customary to limit the working load to that allowed on the wood pile, except in such cases as a portion of the carrying capacity can be developed in the upper soil. This is sometimes accomplished by the use of a heavily-tapered concrete section.

OTHER TYPES OF PILE FOUNDATIONS

The Raymond organization with its large equipment and personnel is in position to and does execute foundation contracts involving practically all recognized and accepted types of piles, including wood piles, steel pipe piles—both closed and open end, reinforced concrete bearing and sheet

piles, and steel and wood sheet piles. In a catalog of this nature, particular comment as to the various types seems unnecessary since the character of such work is not unusual and seems to be generally known.

RAYMOND STANDARD TAPERED PILES

From the standpoint of general use and acceptance, the tapered type of pile has led all others in the concrete pile field for the past thirty-five years. Its successful experience, its record of usefulness, and its sterling performance have been the dominant factors in the development of the concrete pile industry in the United States and in many places abroad.

The value of the taper has been proved in literally thousands of structures of infinite variety, ranging from small dwellings to mammoth industrial buildings and towering skyscrapers. Structures resting on tapered concrete piles dot the United States, are found in the Philippines, China and Sumatra, and from Newfoundland to the Argentine Republic.

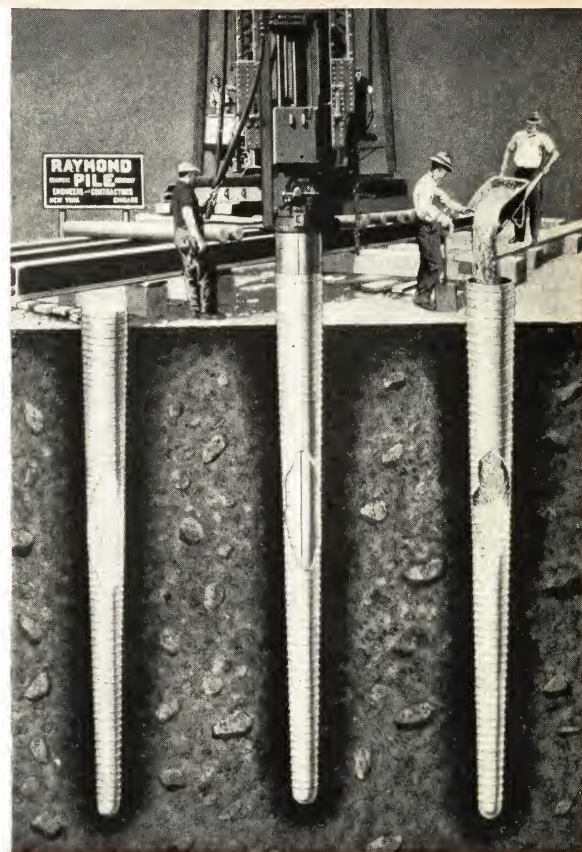
THE RECOGNIZED VIRTUES OF THE TAPER

1. The maximum of bearing value is developed in every square inch of soil in contact throughout the pile's entire length.
2. Due to the tapering wedge shape, the *pile cannot settle the smallest fraction of an inch without forcing lateral movement* of every square inch of soil in contact with its surface.
3. It follows that, except for point bearing conditions, *tapered piles assure the desired load carrying capacity with shorter lengths* than would be required if parallel-sided piles were used—or conversely, should tapered and parallel-sided piles be driven to the same length, *the tapered pile will carry the greater load.* (See curve on page 22.)

COMPARATIVE BEARING TEST OF TAPERED AND STRAIGHT PILES:

The record of a test conducted to ascertain the relative carrying capacity of straight and tapered piling is given on the following page.

This test was made under the supervision of a prominent engineer, who contended that, for the soil in question, a parallel-sided pile possessed certain advantages over a tapered pile. This engineer's attitude was based on the belief that increased surface area was the principal factor increasing carrying capacity.



Cut-away views of RAYMOND TAPERED CONCRETE Piles at successive stages of installation—CENTER, pile driven to grade —LEFT, ready for inspection—RIGHT, concrete being poured.

A large group of RAYMOND TAPERED CONCRETE Piles complete and ready for footings—Note spacing, alignment and uniform grades.



RAYMOND STANDARD



Above left: 96' Steel Driver, driving STEP TAPERED CONCRETE Piles up to 88 feet in length—New York City Exhibition Building at New York World's Fair.
Above right: 50-ton Raymond Driver running on gantry with clear span of 55 feet—driving RAYMOND CONCRETE Piles on 1-to-4 batter—Foundation piers Gen. Pulaski Skyway, Jersey City to Newark, N. J.

To make sure on this point, two piles, each twenty feet long, were driven within a few feet of each other. "Pile A," was six inches in diameter at the point and twenty inches in diameter at the top, while the other, "Pile C," was thirteen inches in diameter at the point and eighteen inches in diameter at the top. "Pile C," with the large point, drove fairly hard from the start, and required nine hundred and forty-four blows of the steam hammer to secure a penetration of twenty feet. "Pile A," with the smaller point, started easily and required only eight hundred and seventy-five blows to secure twenty feet of penetration.

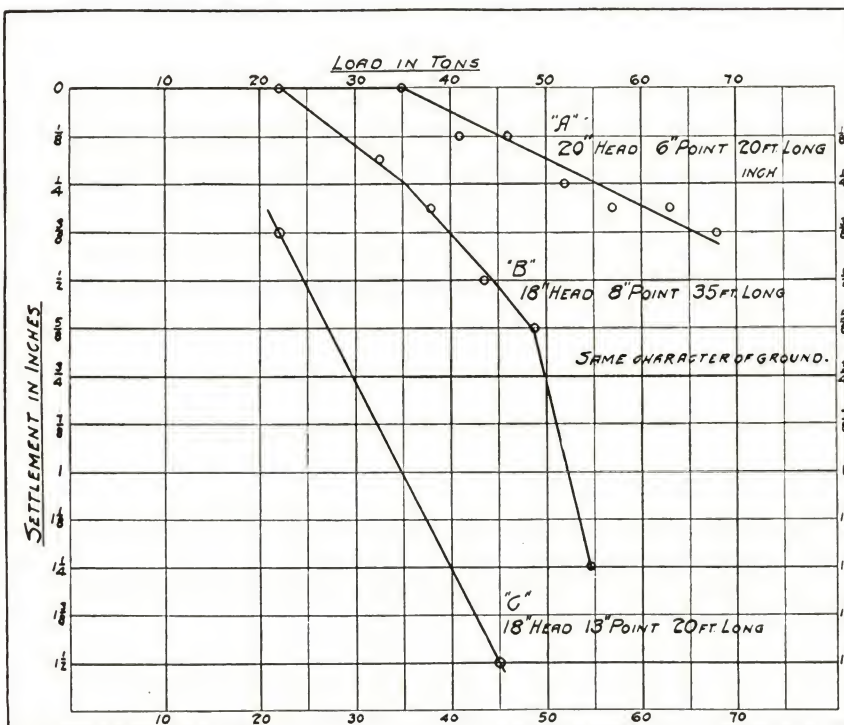
RESULT OF TEST

At the expiration of a month, both piles were loaded and carefully tested. The test showed that "Pile A," the pile with the greater taper, carried a proportionately greater load, showing no appreciable settlement up to sixty-five tons, whereas "Pile C," the less tapered pile, showed the same settlement with a load slightly more than twenty tons. The result is particularly interesting in view of the fact that the engineer who made the tests did so for the specific purpose of showing that a pile of large surface area had greater carrying capacity than a pile which, even tho smaller, was more heavily tapered. The results of these tests have been confirmed time and time again in the course of our experience.

OBSERVATION OF PENETRATION DURING DRIVING

Since in placing a Raymond pile the weights of the driving core and hammer are constant, and since the method of installation is such that one pile must be like another, it is possible to determine the safe load each pile can be relied upon to support. This is done by observing the penetration under each blow of the hammer, and by noting the final resistance as measured in terms of average penetration per blow for the last inch.

Analyzed in the light of experience with soils of the same general character, records thus taken constitute a method of measuring resistance with practically as much certainty as testing the pile with an actual load. Furthermore, each individual pile is in actual practice submitted to this test,



so that definitely known bearing values are established at each point where loads are concentrated. Load tests are sometimes made, but in the majority of instances the driving test described above is of more value, since it is applied to each pile, and does not entail the delay nor the expense incident to loading for test purposes only.

COMPARATIVE COST OF TAPERED VS. NON-TAPERED PILES

The failure to appreciate the greater carrying capacity of the tapered pile has unexpectedly increased the cost of many concrete pile foundations, contracts for which were awarded solely on the basis of the lowest price per lineal foot.

It is well known that the "per foot price" of piling, whether wood or concrete, is in a measure inversely proportional to the number of lineal feet involved in the contract. It is, therefore, obvious that the bidder who bases his price per foot on the use of a pile of uniform diameter throughout its length may realize that, unless the site over-lies hardpan or rock, he will obtain a very much greater average length of pile than will his competitor who bids on a tapered pile.

The curve on opposite page showing the carrying capacities of piles of unequal taper is interesting as indicating the economy of tapered piles from the standpoint of relative length. The thirty-five foot pile shown measured eight inches in diameter at the point and eighteen inches at the top. On account of its less taper, however, it was possible to secure a penetration some fifteen feet deeper than with the twenty foot pile having a greater taper. Notwithstanding the increased length, the test showed the carrying capacity of a thirty-five foot pile to be less than that of the short pile.

CONSTANT INSPECTION:

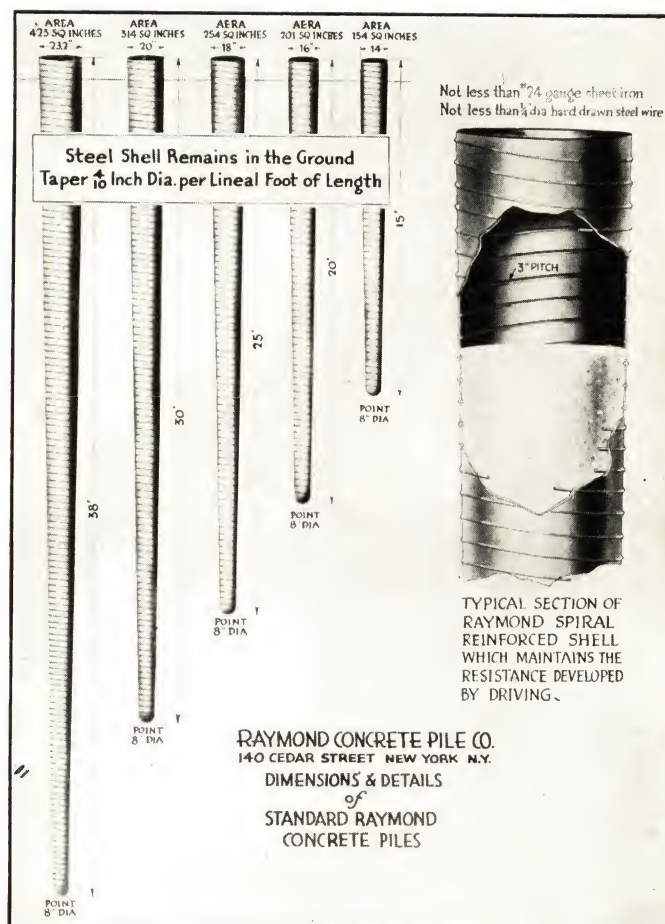
Attention is directed to illustrations showing the construction of the "left-in-place" shell made of steel of the proper gauge, and spirally reinforced to the degree which examination of each pile, after driving, shows to be adequate. This means inspection after every operation is complete, except the pouring of the concrete. Thus the hazards of distortion and loss of resistance are eliminated. Full

cross-section is assured, and the size, shape, and value of the pile become, and remain, known quantities.

OVERCOMING ANY DEFECTS

Should it appear, upon inspection, that a shell has been torn or otherwise injured in driving, or should unsuspected and unusual pressures develop at some point, resulting in the entrance of water or other foreign substance, the defect can be immediately remedied by the insertion of another shell and driving it to resistance before the concrete is poured. Any distortion that may occur in a pile made without a form, or with only a temporary form—any fracture that may occur in the driving of a pre-cast pile—must of necessity remain hidden. Subsequent settlement, perhaps, may call attention to the existence, though not to the extent nor the nature, of the concealed fault.

The Raymond Pile is the only economical concrete pile which offers opportunity for timely inspection.



RAYMOND

STEP TAPERED CONCRETE PILES

Early in the year 1931, the Raymond Company developed the Step Tapered Concrete Pile, embodying the fundamentals of the original Raymond Standard Pile, but permitting of increased lengths up to 100 feet and more.

It is, of course, impossible to mention all of the various soil conditions encountered where Step Tapered piles have provided an economical solution, but the following are typical:

A Unstable soil of doubtful or indeterminate supporting value to a depth of 30' or more below the surface, and underlain by stable materials such as rock or hardpan or perhaps sand, gravel or stiff clay, into which the pile points may be driven (a greater or less distance, according to character and density of the material itself) to firm calculable bearing.

B Hard soil, difficult of penetration though unreliable for bearing on account of yielding strata below, which must be penetrated by the piles.

C Alternate strata of hard and soft materials necessary to be penetrated before firm bearing can be reached.

The step tapered pile has, to a remarkable degree, received universal acceptance on the part of the engineering, architectural and construction world. Illustrative of this, it may be of interest to note that since the first commercial use of this type of pile in 1931, the Raymond Company has, on the average, completed every week, a step tapered pile contract of 280 piles, involving more than 11,000 lineal feet each. The clientele making use of this type of pile to meet its special requirements classifies roughly as follows:

	<i>No. of Projects</i>	<i>No. of Piles Exceeding</i>	<i>No. of Lin. Ft. Exceeding</i>
U. S. Government projects	15	24,000	697,000
Oil Companies	6	6,900	253,000
States, Counties and Municipalities	38	14,000	496,000
Railroads, Viaducts, Grade Separations, Terminals, etc.	6	2,100	74,000
Automobile Plants	6	6,200	315,000
Steel Plants	7	15,600	800,000
Miscellaneous Industrial Structures	27	8,400	280,000
Other Miscellaneous Structures, such as Office Buildings, Schools, Churches, etc.		3,000	650,000

Raymond Steel Pile Driver with STEP TAPERED Core and Shell—Shell, screwed together into single unit, has been lowered into adjacent open driven shell and is being drawn up over the core, ready to be driven.

FOR PILES UP TO 100 FEET LONG AND OVER

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3

Geographically the projects above described have been located in the various States ranging from coast to coast and from the Canadian border to the Gulf. Individual projects have involved as many as 12,000 piles and as few as 8. Lengths have varied from 16 to 115 feet and underlying soil conditions have in many cases been peculiarly difficult. The piles in some instances have been driven through fill and silt to rock bearing; some through layers of hardpan, heavy gravel and sand overlying silt and other yielding soils; others have been drilled, blasted, jetted and driven through slag layers and soft clay, and still others have been jetted through fine sand for their full length, demonstrating the tightness of the shell against the intrusion of water and the finest running sand.

As in the Raymond Tapered Pile heretofore described, the step tapered pile is installed by driving an inner core completely encased in a strong steel shell. After proper penetration and resistance is secured, the core is withdrawn and the shell, which is left permanently in the ground, is filled with concrete. Again, retaining the most essential feature of the Raymond system, this shell remains in intimate contact with the ground, thus maintaining the original driving resistance in the completed pile.

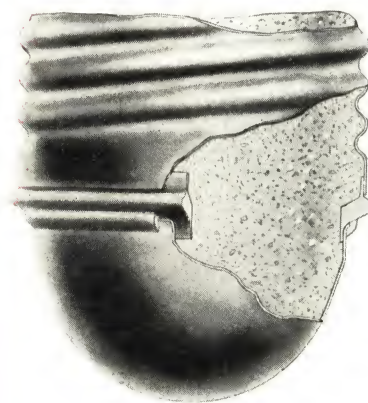
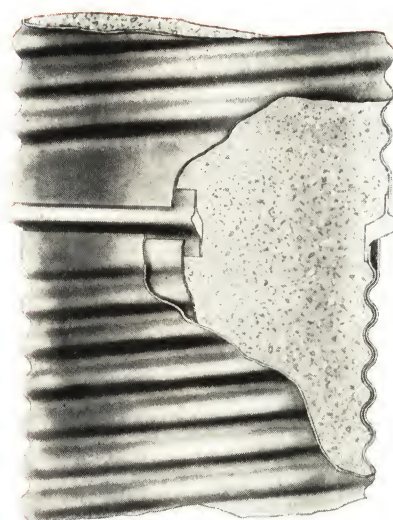
This method provides assurance that the pressures and soil contacts generated in driving will not be released and the carrying capacity of the pile thereby impaired; thus removing a hazard always present if an exterior driving pipe or casing is withdrawn.

The shell of a step tapered pile is usually corrugated and is of such substantial construction that it protects the recently filled shell from distortion during the driving of adjacent piles, at the same time providing a watertight form to prevent the admixture of ground water or other foreign materials with the concrete.

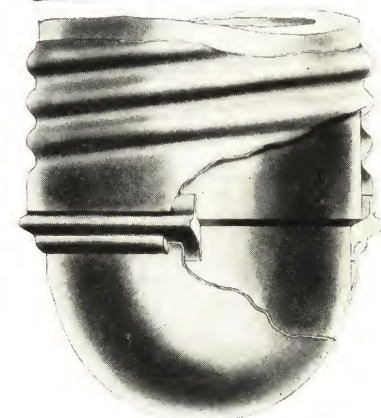
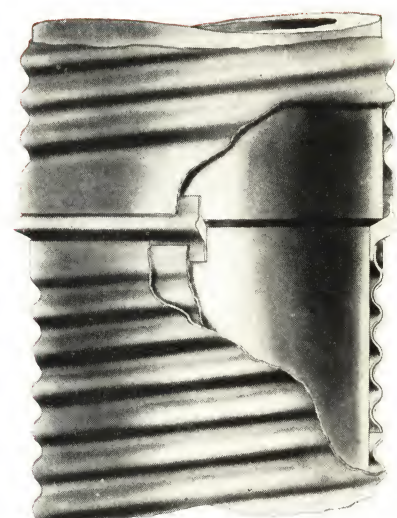
These features completely eliminate the hazards of imperfect concrete construction, since the shell (the form into which the concrete is poured) is visible for inspection before being filled.

Attention is directed to the illustrations below. From this cutaway photograph, it will be seen that the heavy hollow-walled core has a "stepped" outer surface and that the steps which are beveled as shown bear directly on the beveled surface of the plow ring welded to the lower end of each 8' shell section.

25



Cut-a-way of lower section
RAYMOND STEP TAPERED Pile.



Cut-a-way showing STEP TAPERED
SHELL and CORE shoulder bearing
on shell.

RAYMOND STEP TAPERED



STEP TAPERED Pile partially driven.

To the lower projecting fin of this plow ring it will be observed that a short spirally corrugated inner sleeve has been welded, thus permitting the lower section to be screw-connected to the upper. It will also be noted that the lower end of the core is rounded and is covered by a heavy gauge pressed metal "boot" which is welded to the lowest plow ring.

The core is "solid" since the construction of the shells makes it unnecessary to use a collapsible core as is required for Raymond Standard piles. Various lengths and sizes of cores are built to fit the shells required for the particular jobs. Illustrations herein show the core completely enveloped in the several sections of shell which are all screw-connected and usually assembled before being placed on the core.

The usual dimensions of step tapered piles are as follows:

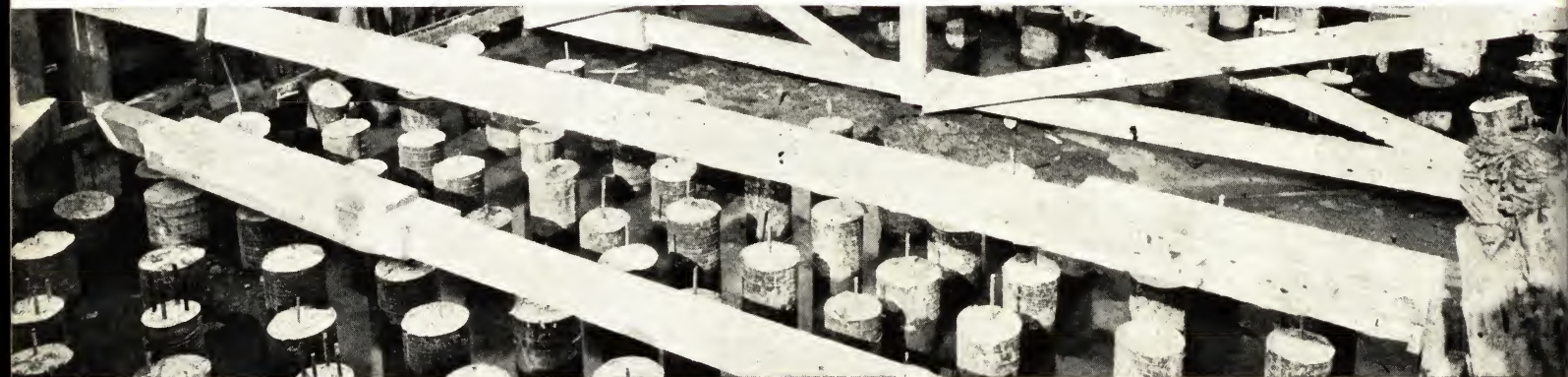
<i>Length</i>	<i>Top Diameter</i>	<i>Point Diameter</i>
56 feet	15 $\frac{7}{8}$ "	9 $\frac{3}{4}$ "
48 "	15 $\frac{7}{8}$ "	10 $\frac{5}{8}$ "
40 "	14 $\frac{7}{8}$ "	10 $\frac{5}{8}$ "
* 32 "	13 $\frac{7}{8}$ "	10 $\frac{5}{8}$ "
* 24 "	12 $\frac{7}{8}$ "	10 $\frac{5}{8}$ "
* 16 "	11 $\frac{7}{8}$ "	10 $\frac{5}{8}$ "

* When for any reason a greater cross-section appears to be desirable, it is possible to accomplish this by removing the lower sections of the core and using two or more of the upper sections with driving points of corresponding size adapted thereto, thus:

A pile 32' in length might have a top diameter of 15 $\frac{7}{8}$ " and a point diameter of 12 $\frac{7}{8}$ ", or

A pile 24' in length might have a top diameter of 15 $\frac{7}{8}$ " and a point diameter of 13 $\frac{7}{8}$ ", or

Other combinations may be used to suit the requirements of a particular situation.



CONCRETE PILES (Continued)

The appearance and general characteristics of the step tapered shell are fairly well shown in the illustration to which attention has been directed above, but it may be added that the gauges of metal used generally vary from 20 to 14 but are, in some instances, as heavy as 10 and as light as 22 and 24, depending altogether upon the nature of the soil to be penetrated and the pressures to be retained, the lighter weight section naturally being used nearer the surface of the ground. All seams of the shell sections are electrically welded watertight.

Each of the heavy beveled plow rings as shown on the sketch contacts the corresponding shoulder on the core. The hammer blow is in this manner transmitted through the core to the shell and, by reason of the sturdiness of this beveled ring, without injury to the shell.

On several jobs where the step tapered pile has been used, driving conditions have been so severe that it has been necessary to continue the driving to a degree of hammer resistance heretofore unknown. For instance, on one pile we have a record of driving with a 5000 lb. hammer falling 3' and operating sixty blows to the minute for a period of 63 minutes and, in another instance, a total on one pile of more than 5200 blows with a No. 1 hammer to secure a penetration of about 31 feet in order to reach rock. In both instances, upon withdrawal of the driving core, the shell was found to be undamaged and a perfect form for the concrete.

STEP TAPERED Shell ends—showing plow ring and screw collars for joining into full length shell unit.



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Right: Pier of RAYMOND STEP TAPERED Piles ready for the footings.

Below: STOCK Pile of STEP TAPERED Shells nested as shipped.



CONCRETE PILE SPECIFICATIONS

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The following specifications for cast-in-place piles and an alternative specification for precast piles conform with the general requirements of all the principal cities in the United States, for piles up to 60 ft. in length. For piles in excess of 60 ft. in length, these specifications should be modified slightly. The Raymond Concrete Pile Company's representative will be glad to discuss these modifications in detail.

CONCRETE PILES:

Where indicated on the drawings, furnish and place the required number of concrete piles as specified, to support the foundations. Excavation shall be made to the pile cut-off before any piles are driven. Concrete piles shall be either cast-in-place or precast piles.

CAST-IN-PLACE PILES:

Cast-in-place piles shall have steel shells driven to the required bearing, the shells being left permanently in place and filled with concrete. All shells shall be of sufficient strength and rigidity to permit of their driving, and to prevent distortion caused by soil pressures or the driving of adjacent piles. The shells shall also be sufficiently water-tight to exclude water during the placing of the concrete.

Piles shall be cylindrical or tapered. If tapered, they may be either of a constant increase in diameter or uniformly stepped. The minimum diameter of cylindrical piles shall be 14", and the minimum diameter of tapered piles shall be 8" at the point and 14" at the head. The average diameter shall be not less than 11".

Concrete shall be composed of one part approved Portland cement to three parts clean, sharp sand, and five parts of gravel or crushed stone of suitable quality, thoroughly mixed and properly proportioned as to water content. All coarse aggregate to pass a $\frac{3}{4}$ " ring.

The use of piles in which fresh or unset concrete is placed against the soil will not be permitted.

PRECAST PILES:

Precast piles shall be of uniform cross-section or tapered, and shall have at least an average cross-section area of 196 square inches up to 20' in length and 225 square inches if in excess of 20'. They shall be reinforced with longitudinal reinforcing steel not less than 2% of the average gross cross sectional area of the pile and any additional reinforcing steel necessary to take care of the stresses due to handling or driving. Lateral reinforcing shall consist of $\frac{1}{4}$ " diameter hoops spaced 12" on center for the full length of the pile, excepting for 3' at the head and point where the hooping shall be not over 3" on center. There shall be at least 2" of concrete protection outside the reinforcing steel.

Forms shall be tight and rigid to prevent leakage or distortion. All piles shall be plainly marked with the casting date and shall be cured for a period of 30 days and shall not be handled or removed from the casting platform prior to this time without the approval of the Engineer. Piles must be cured at an even temperature in order that they may get a proper set; therefore, in warm weather they should be kept moist for a time, while in cold weather they shall be heated until they have properly set and cured. If cast in tiers, the lower piles shall be at least 14 days old before any superimposed load is placed upon them.

If precast piles are used, the Contractor shall drive enough test piles to predetermine the length of pile required to secure the specified bearing and required penetrations in the various areas of the work. These tests shall be made sufficiently in advance of the

pile driving to prevent delay in the progress of the work, and to enable the Contractor to have on hand at all times, piles of proper length to meet any condition that may arise.

Concrete shall be composed of one part approved Portland cement to two parts of clean, sharp sand and four parts clean gravel or crushed stone, thoroughly mixed and properly proportioned as to water content.

DRIVING:

All piles shall be driven to a resistance satisfactory to the Engineer, by such methods as will not impair their strength and as will insure the retention of that resistance.

Jetting shall only be done when permitted by the Engineer. When piles are jetted, they shall be driven to the required resistance after jetting has ceased.

The driving of all piles shall be continuous, without intermission, until the pile has been driven to its final resistance.

All cushions must be approved by the Engineer. No free swinging leads will be permitted, and the equipment shall provide adequate support to firmly hold the pile in correct position while being driven.

The pile shall be driven to a sufficient depth to carry the imposed loads, and the Engineering News formula shall be considered to indicate the load that can be safely supported by a pile. The pile driving hammer shall develop an energy per blow of at least 12,000 foot pounds.

PAYMENT:

All piles shall be measured from the point to the cut-off elevation shown on the plans. No payment will be made for withdrawn, broken or rejected piles, nor for portions of piles remaining above the cut-off.

The following is a suggested specification for use when conditions indicate the desirability of composite piles.

COMPOSITE PILES:

Composite piles shall consist of a concrete section from the bottom of the footing to 1' below water level, superimposed upon a wood pile of suitable size and length. The concrete portion of the pile shall be of such cross-section that the load placed upon it shall not exceed 350 lbs. per square inch of area. The wood pile shall have a minimum diameter of not less than 13" two feet from the head and a minimum diameter of 6" at the point, except that where piles exceed 60' in length point diameters may be not less than 5".

Wood Pile Section:

All piles shall be sound and free from sharp crooks or bends and sufficiently straight so that a line drawn from the center of the head to the center of the point will lie wholly within the pile. The joint between the concrete and wood sections shall be so constructed as to exclude water or other foreign materials and shall be of sufficient strength so as to provide against an uplift of 10 tons without separation.

Concrete Pile Section:

Concrete shall consist of one part approved Portland cement, two parts clean, sharp sand, and four parts clean gravel or crushed stone, thoroughly mixed and properly proportioned as to water content; all coarse aggregate to pass a $\frac{3}{4}$ " ring. In no case shall fresh or unset concrete be placed in contact with the surrounding soil.

UNDERPINNING

UNDERPINNING is generally incidental to:

- (a) The protection of structures already in place from settlement damage due to nearby operations, such as adjacent basement, sewer, or other excavations being carried to or below the elevation of the original footing.
- (b) The necessity of correcting original foundation errors where settlement has developed due to compression of the soil or its escape horizontally under pressure.
- (c) The necessity of reinforcement of the foundation in order to provide for additional stories or other increased loadings, sometimes because of changes in the uses of the building itself.

The particular type of underpinning most suitable will depend largely upon the character of the original foundation, the design of the substructure, and the conditions under which the underpinning must be carried on with the least disturbance to current normal operations.

VARIETY IN TYPE OF UNDERPINNING

Under certain conditions, sectional piles jacked down to suitable bearing, and using the original walls and footings for reaction, are the most practical and economical. In other cases, caissons are preferable. Under still other circumstances, it is desirable to carry the original footings deeper to a better subsoil bearing. *In any case* under consideration, it will be the part of wisdom to seek experienced counsel and to write specifications which will permit of the most intelligent handling of all existing problems.

CAISSONS

Caisson foundations are of four general types:

1. **OPEN CAISSONS**—Where soil conditions are such that excavation can be carried to suitable bearing material without passing thru “quick” or running sand strata or strata bearing water in greater quantity than can be handled by moderate pumping operations.

2. **GOW CAISSON PILES**—Caissons of this type are installed by the Gow Division of the Raymond Company, and, when ground conditions are suitable, are probably the least expensive type of caissons.

Excavation is usually done by hand inside of steel cylinders, each cylinder being approximately 8' long. A shallow starting pit is excavated first and the top cylinder is driven down in this pit. The soil inside this cylinder is then excavated. A second cylinder about 2" smaller in diameter is then placed inside the first one and is driven down. The soil in the second cylinder is excavated and the entire process is repeated until the caisson reaches its full depth. Each cylinder is about 2" smaller in diameter than the one next above it and the lowest cylinder must be of the specified shaft diameter. This lowest cylinder is driven into the final bearing stratum to seal off. Where necessary the soil below the bottom cylinder is “belled” out to provide the bearing area required for the specified unit soil pressure.

The lower section is then filled with concrete and the lower cylinder withdrawn thru the larger section immediately above. The next cylinder is then filled and withdrawn, and the process repeated until all are refilled and all withdrawn, leaving the completed caisson in place, belled out from shaft diameter at the bottom and increasing in diameter by 2" steps in each eight feet up to the elevation of the footing or column base.

Machine excavations—where soil conditions and other factors are suitable, the excavation of the shaft is accomplished by means of a rotary excavating machine developed by the Gow Division. When machine excavation is practicable, a substantial saving in time can be effected with consequent economy.

The economy of this type of caisson is due to re-use, and salvage, of the cylinders which only temporarily line the excavation, and also to the lack of heavy equipment and overhead requirements.

3. **PNEUMATIC CAISSONS**—In which operations are carried on under compressed air at pressures up to 48 lbs. per square inch, necessitating air locks thru which workmen and materials enter and are removed. The process, involving, as it does, heavy and costly plant, short shift hours for the workers and relatively slow progress, is necessarily expensive and is seldom employed where any other method appears feasible. There are, however, certain conditions under which the pneumatic caisson seems to furnish the only solution;—such, for instance, as installing the caissons for a new building while the structure it is to replace is still in use and where soil conditions are such as to preclude the adoption of any open caisson method.



Excavation for Underpinning



Installation of GOW CAISSON Piles—Note 3 steel cylinders partially exposed in foreground.



Steel Cylinders (nested for transportation) used in GOW CAISSON Pile Process.

Below: Excavating Bucket at end of telescoping shaft of Gow Rotary Excavating machine—Note reaming knives at top of bucket.



4. THE WET PROCESS CAISSON—Installed by the Caisson Contracting Company, whose operations are under the supervision of the Raymond Company as consultants. This process is applicable to practically every condition which, prior to its development, necessitated the use of the more expensive pneumatic type.

METHOD OF INSTALLING—The Wet Process caisson is installed by methods similar in some respects to the drilling of oil wells. Excavation, down to the level of hardpan or boulders, is done by what is known as "spud drilling," which means that the drill itself—a spider-like member with arms radiating from the center to the full caisson diameter—is attached to the lower end of a hollow drill stem 10" to 12" in diameter. On the arms of the "spider" are mounted cutting or scarifying teeth.

The drill stem is rotated from the top end and water under heavy pressure forced down thru it, emerging at the point to assist the cutting action and partially emulsify the material scraped and broken up by the drill. A considerable portion of such material will remain in suspension, rising to the top under the continuing water pressure and overflowing into nearby conducting trenches, or pipe, into an adjacent sump. The heavier solids settle to the bottom of the sump, and the light, mud-laden fluid is recirculated thru the drill stem instead of clear water.

The final result of these operations is, that down to the level of material impenetrable by the spud drill, the full size caisson excavation is filled with a fluid of considerably greater specific gravity than water. Loss of drilling fluid into the soil is prevented by the "mudding up" action of the drill, which plasters the walls of the hole with clay which, when not encountered in the soil, is added to the drilling fluid for this purpose. As long as this liquid remains in place, and hydrostatic pressure is not unbalanced by its removal, the walls of the excavation will remain intact without material caving.

INSTALLING THE STEEL CYLINDER—The next step in the process follows—the first step, of course, being the removal of the drill. If by the spud drilling process above described, the final bearing strata has been reached, a steel cylinder of finished caisson diameter and length is lowered into the mud-laden hole and driven to final seal in the bottom material. The fluid and residue of settled solids in-

side the cylinder are then removed by pumping, clam shell or orange peel bucket, or other methods, and the bottom cleaned and inspected, after which the concrete is poured in the ordinary manner.

In some instances, the cylinder (or casing) is withdrawn immediately upon the pouring of the concrete and is re-used. This may be safely done under certain conditions, and is, of course, economical.

DRILLING AGAINST OBSTRUCTIONS—If before final bearing elevation is reached, the spud drill ceases to penetrate satisfactorily, due to obstructions or material which will not readily yield to that type of drilling, the spud drill is withdrawn and a "core barrel" drill is lowered to the bottom then reached. Sufficient casing is connected to the core barrel to reach to the surface. The core barrel, usually has a double wall with an annular space of about $\frac{3}{8}$ " between walls, with inner projecting lugs having drilled water leads to the annular inner wall space.

The drill stem is then lowered to connect with the core barrel by means of a spider, in the drilled arms of which are holes connecting with the water leads in the lugs. The drill stem is then rotated. It turns the core barrel and casing clockwise by contact with the core barrel lugs, with water under heavy pressure feeding thru the drill stem, the spider arms and the core barrel lugs, to the walls of the core barrel, and out thru its extreme end. This entire assembly constitutes a core drill cutting a circular channel thru all obstructions to a seal in the rock below.

The cutting action is usually assisted by feeding into the water system, hardened steel shot. This shot finds its way down thru the drill stem spider arms, lugs, and core barrel walls, and finally out thru slots in the cutting edge where it serves as the abrasive between the bottom surface of the core barrel and the rock. In some instances, shot is not required, there being sufficient natural abrasive material encountered to enable the core barrel edge to grind its way into the rock, usually penetrating 6" to 1', thus forming a seal which is adequate to permit of the caisson being unwatered and the concrete placed substantially in the dry. The operations of unwatering, removing the settled solids and placing the concrete are as hereinbefore described in connection with wholly spud drilled caissons.

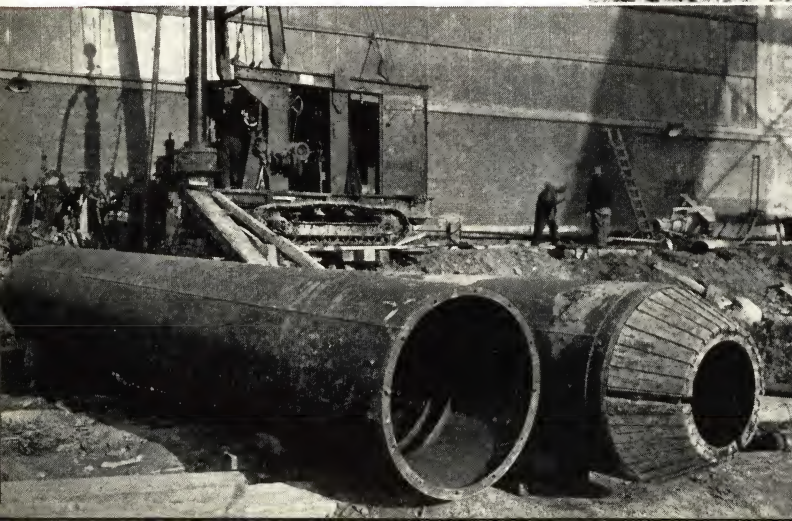
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Center: SPUD DRILL used in WET PROCESS TYPE CAISSON—Note apertures for water emergence at point and attached section of drill pipe—also cutting teeth attached to drill arms.

Below: Cylinder Sections used in WET PROCESS TYPE CAISSON.



Below: Lowering steel casing into spud drilled hole thru mud fluid which balances hydro-static head and prevents caving—Two sections of drill pipe in foreground—Rotary drilling machine in right background—WET PROCESS TYPE CAISSON.



HARBORS - PIERS - WHARVES and TERMINALS

SHORE PROTECTION •

JETTIES • BRIDGES •

TUNNELS • TRESTLES •

RETAINING WALLS •

DAMS •

HYDRO-ELECTRIC
PLANTS •

RIVER
IMPROVEMENTS



Highway Bridge over Peace River at Punta Gorda, Florida — Reinforced concrete structure 4375 feet long, 34' 10" wide, on 756 RAYMOND PRECAST CONCRETE PILES 65' to 75' long.

The illustrations following will serve to show partially the character and scope of the Raymond Company's activities in other fields than foundation work. As to

many of these projects, the Company's connection has been continuous from the stages of preliminary survey and reports, thru the processes of planning and design, on to complete construction and, in some instances, operation subsequent to completion.

Each separate project has had its own problems, and, naturally, each has required its own special treatment. Each successive accomplishment has added to the knowledge and experience of the organization . . . broadened its

equipment for the next problem. The process of education seems never to be complete, and valuable lessons learned in the development and carrying out of nearly every contract, are remembered, and applied, to the benefit of succeeding ones.

All of which further emphasizes the importance of seeking experienced counsel and early co-operation.

May we be of service to you?

Raymond Concrete Pile Company

HARBORS, PIERS, WHARVES, TERMINALS, JETTIES, ETC.



Section, during construction, of reinforced concrete sea wall on Lake Pontchartrain (La.)—over five miles long—for Orleans Levee Board. Supported on reinforced concrete bearing and batter piles and a cut-off wall of tongue and groove reinforced Concrete Sheet Piles.



Concrete Wharf and Cold Storage Warehouse for City of Mobile J. B. Converse & Co., Engineers. Raymond Concrete Pile Co., Contractors.



Gantry handling 65 ft. Precast Piles from casting yard—Bridge over Peace River at Punta Gorda, Florida.



Under view of 4½ mile reinforced concrete bridge across Lake Pontchartrain, near New Orleans, Louisiana—Note perfect alignment to vanishing point.



Boca Ciega Causeway near St. Petersburg, Florida—length 2800 ft., width 30 ft. This was one of three similar structures built by the Raymond Company under the same contract.



Retaining the waters of Lake Maracaibo, Venezuela, S. A.—Reinforced concrete sheet pile water-tight dyke, 2.73 miles long.



Rear view, showing 80 ft. composite spur piles—Temporary falsework wood piles in foreground.

Raymond Concrete Pile Company

THE SCOPE OF RAYMOND ACTIVITIES

2
3

On the theory that past performance is the best indication of what may be expected in the future, previous Raymond catalogs have presented fairly complete lists of contracts executed by the Company and its licensees. These lists have shown geographical locations and the names of Owners, Engineers and Architects concerned.

The years that have elapsed since we began this practice have witnessed such a large number of additional contracts completed that publication of anything approximating a complete list has become impracticable. We are therefore presenting the following tabulation of contracts classified as to number and general location. This will enable prospective builders and designers, when interested

in some particular project, to communicate with us and learn what if any experience we have had in that particular locality, as well as the names of projects and personnel concerned. If at the time of the inquiry some definite project is under consideration, the information we may be able to supply will be of maximum value and pertinence.

The tabulation presented will show not only the breadth and magnitude of our past operations but the particular locations in which we have had experience. We invite inquiry from those interested. Of the forty-eight states in the United States, we have placed piles or made borings or built caissons or other types of foundation work in forty, located in 931 cities or towns, as follows:

TABULATION OF CONTRACTS

State	Locations	Contracts	State	Locations	Contracts	State	Locations	Contracts
Alabama	4	6	Louisiana	7	27	Ohio	41	303
Arkansas	12	14	Maine	13	36	Oklahoma	6	18
California	50	222	Maryland	27	433	Oregon	3	17
Colorado	4	6	Massachusetts	173	1999	Pennsylvania	89	613
Connecticut	30	120	Michigan	25	211	Rhode Island	8	48
Delaware	4	10	Minnesota	8	34	South Carolina	5	14
Dist. of Col.	6	151	Mississippi	5	20	Tennessee	8	22
Florida	19	84	Missouri	13	140	Texas	16	52
Georgia	13	52	Nebraska	3	32	Vermont	11	16
Illinois	35	228	New Hampshire	27	113	Virginia	14	77
Indiana	16	40	New Jersey	72	362	Washington	4	11
Iowa	10	35	New York	91	981	West Virginia	21	53
Kansas	8	37	North Carolina	17	32	Wisconsin	9	45
Kentucky	4	9						

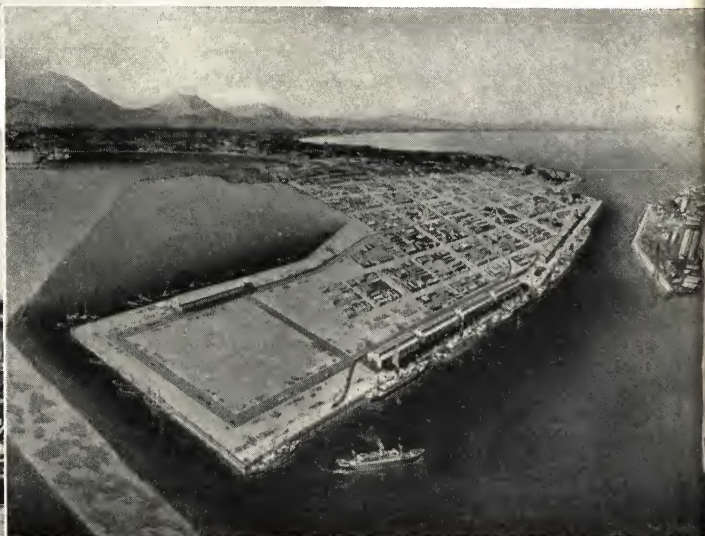
And in the following countries outside of the United States:

Country	Locations	Contracts	Country	Locations	Contracts	Country	Locations	Contracts
Argentina, S.A.	1	4	Cuba	1	1	Mexico	2	4
Canada	27	113	Dutch West Indies	1	2	Panama, C.Z.	2	3
China	2	4	England	1	10	Sumatra	1	3
Colombia, S.A.	5	19	Japan	3	5	Venezuela, S.A.	13	32



Left: One of a large number of OIL WELL DERRICK BASES for Lago, Petroleum Company in Lake Maracaibo, Venezuela.

Below: PIER for Port of Havana Docks Company, Havana, Cuba—2406 PRECAST CONCRETE PILES from 55' to 85' long.



Above: COMPLETE HARBOR DEVELOPMENT at Puerto Cabello, Venezuela for Venezuelan Government.

Below Right: PORT OF RUENAVENTURA, Republic of Colombia, S.A., showing reinforced concrete bulkhead 2376' long—four warehouses 150' x 292'—and newly made land comprising 47.6 acres. Depth of water alongside 32.8 at mean low tide—3412 PRECAST CONCRETE PILES ranging from 35 to 71' in length—work done for Colombian Government.

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Below: Sections of 34" diameter REINFORCED CONCRETE PIPE used for supply line 45,500 ft. long, in connection with water works for the City of Maracaibo, Venezuela — Constructed by Lock Joint Pipe Company and Raymond Concrete Pile Company.



Below: DOCK AND BULKHEAD for Government of Venezuela at Maracaibo, comprising two legs at right angles, one leg 1680 feet and the other 1800 feet long. Forty-five acres of land thus reclaimed for warehouses and public buildings —Note Lighthouse at apex of triangle.

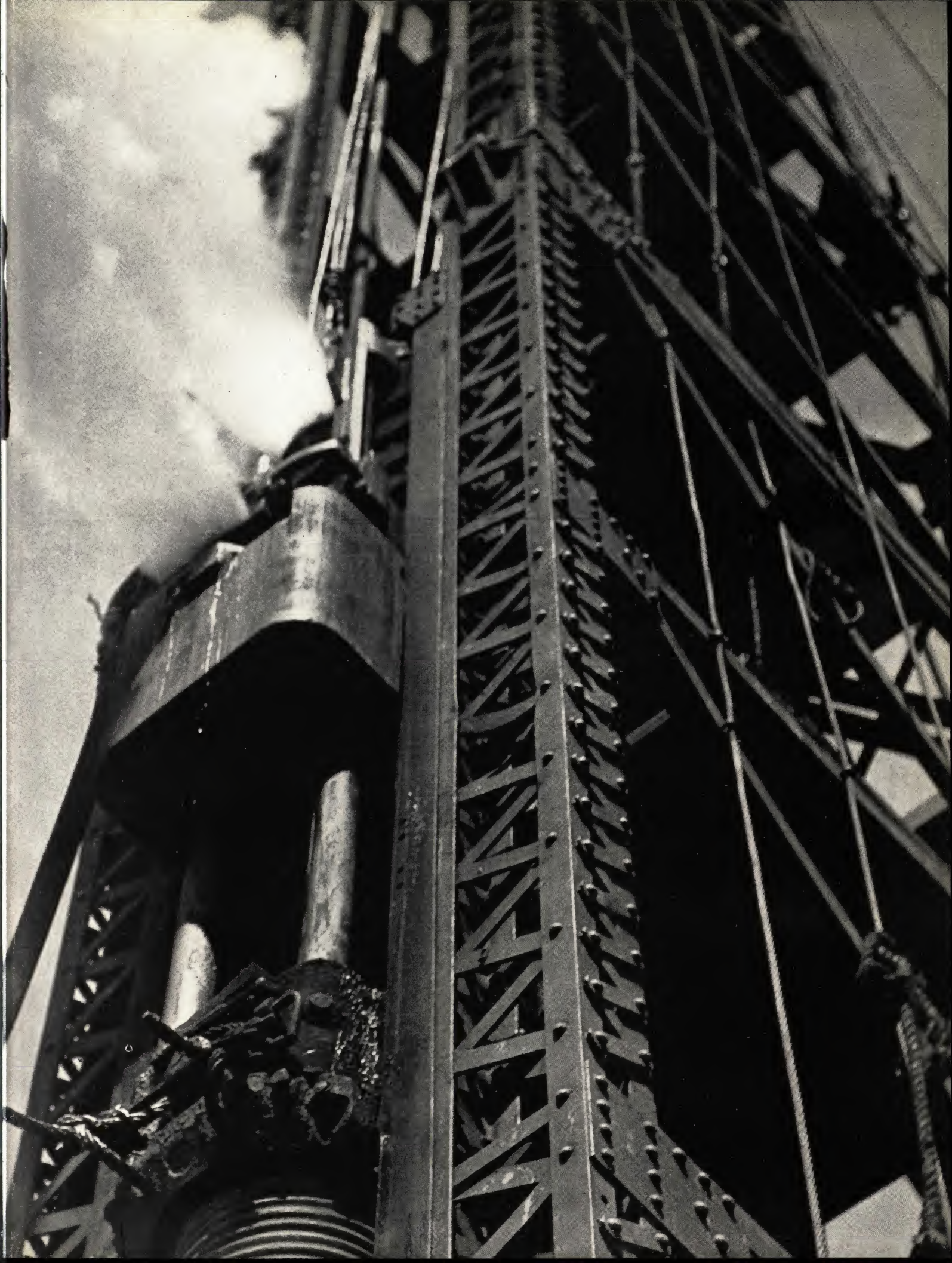


Below: REINFORCED CONCRETE PIER 984' long with warehouses and administration building, for City of Barranquilla, Colombia, 11 miles up Magdalena River from Caribbean Sea—Depth of water 32.8'—Work done for Colombian Government.



Above: Sections of REINFORCED CONCRETE PIPE in transport to supply line location—Waterworks for City of Cartagena, Colombia.





RAYMOND

Concrete Piles

